OPERATING INSTRUCTIONS

TYPE 1133-A

FREQUENCY CONVERTER

1133-A

GENERAL RADIO COMPANY

A

OPERATING INSTRUCTIONS

TYPE 1133-A
FREQUENCY CONVERTER

Form 1133-0100-A
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West Concord, Massachusetts, USA

GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS, USA

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Parts Lists, Schematics, and Service Tables . . . . . Refer to page 19

Figure 1-1. Panel view of the Type 1133-A Frequency Converter.

SPECIFICATIONS

INPUT

Frequency Range: 100 kc to 500 Mc.

Sensitivity (with the Type 1130-A Digital Time and Frequency Meter): Better than 10 mv on narrow band; better than 100 mv on wide band. See Figure 3-2.

Maximum Input: 5 volts.

Impedance: 50 ohms.

Reference Frequency Required: 5 Mc, 0.1 volt rms into 50 ohms (normally supplied from 5-Mc output connector on Type 1130-A).

OUTPUT

Frequency: 100 kc to 10.1 Mc.

Amplitude: 0.25 volt to 1 volt, approximately.

Impedance: 100 ohms, approximately.

Patent No. 2,548,457.

Noise and Harmonics: Narrow-band operation provides filtering to reduce noise and extraneous signals. Linear mixer preserves signal-to-noise ratio during conversion process.

GENERAL

Power Requirements: 105 to 125 (or 210 to 250) volts, 50 to 60 cps, 70 watts.

Accessories Supplied: Two coaxial patch cords for connection to counter, one coaxial cable connector, one three-wire power cord, and spare fuses.

Dimensions: Bench model, width 19, height 7½, depth 17¾ inches (485 by 190 by 450 mm), over-all; rack model, panel 19 by 7 inches (485 by 180 mm), depth behind panel 15 inches (385 mm).

Net Weight: 34 pounds (15.5 kg).

Shipping Weight: 50 pounds (23 kg).

SECTION **1**

INTRODUCTION

1.1 PURPOSE.

The Type 1133-A Frequency Converter (Figure 1-1) is a sensitive, easy-to-use converter which extends the frequency-measurement range of the General Radio Type 1130-A Digital Time and Frequency Meter to 500 Mc. Signals with frequencies between 10 and 500 Mc are heterodyned with a standard reference frequency, derived from the 5-Mc time-base oscillator of the counter, down to the 100-kc to 10.1-Mc range for measurement by the counter. The instrument can also amplify signals between 100 kc and 10 Mc to operate the counter.

If a 5-Mc source is available, the converter can be used with other 10-Mc counters or as part of specialized measurement systems.

1.2 DESCRIPTION.

Operation of the converter is simple and straightforward. The heterodyne reference frequency to be added to the counter reading is indicated directly by in-line numerals. Signal lights are used to indicate proper control settings wherever ambiguity might exist. The range of output amplitude acceptable for the counter is clearly indicated on the panel meter and the adjustment to this level is made by an OUTPUT control. An input SENSITIVITY control is also provided.

The Type 1133-A Frequency Converter is mounted in a heavy-gauge aluminum cabinet fitted with aluminum end frames for bench use. With the end frames removed, the instrument can be mounted in a standard 19-inch relay rack.

1.3 ACCESSORIES SUPPLIED.

Supplied with the instrument are a Type CAP-22 Three-Wire Power Cord, a short Type 874-4220 Patch Cord to connect to the input of the Type 1130-A Digital Time and Frequency Meter, a Type 874-R22A Patch Cord to connect the 5-Mc output of the counter, a Type 874-C58A Cable Connector, and spare fuses.

SECTION **2**

INSTALLATION

2.1 LOCATION

The converter is normally located below the Type 1130-A Digital Time and Frequency Meter as shown in Figure 2-1.

2.2 MOUNTING.

The instrument is available for either bench or relay-rack mounting. For bench mounting (Type 1133-AM), aluminum end frames are supplied to fit the

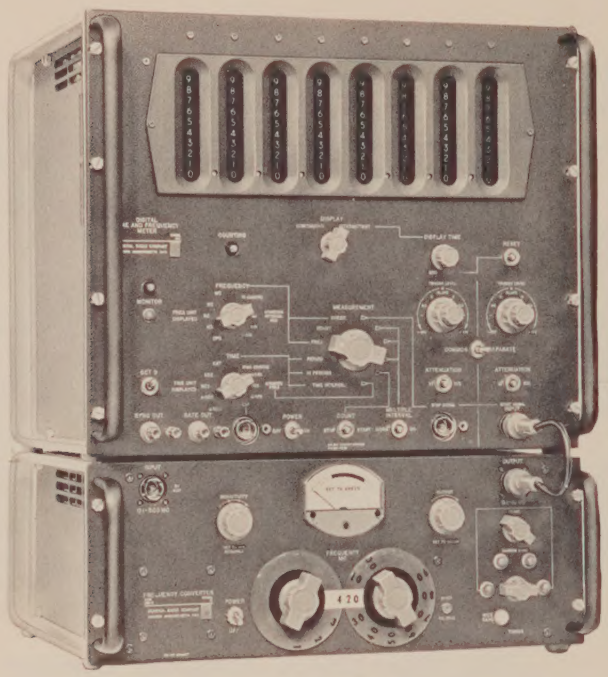


Figure 2-1. The Type 1133-A Frequency Converter with its companion instrument, the Type 1130-A Digital Time and Frequency Meter.

ends of the cabinet. Each end frame is attached by means of two panel screws and four 10-32 round-head screws with notched washers.

For rack mounting (Type 1133-AR), the end frames are removed and special brackets are supplied to attach the cabinet and instrument to the standard 19-inch relay rack (see Figure 2-2). These brackets permit either the cabinet or the instrument to be withdrawn independently of the other.

To install the instrument in a relay rack:

a. Attach each mounting bracket (A) to the rack with two 12-24 round-head screws (B). Use the inside holes on the brackets.

b. Slide the instrument onto the brackets as far as it will go.

c. Insert the four panel screws with attached washers (C) through the panel and the bracket, and thread them into the rack. The washers are provided to protect the face of the instrument.

d. Toward the rear of each bracket, put a thumb screw (D) through the slot in the bracket and into the hole in the side of the cabinet.

e. On the rear of the cabinet, remove the two round-head screws that hold the cabinet to the instrument.

To remove the instrument from the rack, remove only the four panel screws with washers (C) and draw the instrument forward out of the rack. To remove the cabinet and leave the instrument mounted in the rack, remove only the two thumb screws (D) at the rear of the brackets and pull the cabinet back off the instrument from the rear of the rack.

2.3 CONNECTION TO POWER SUPPLY.

Connect the Type 1133-A to a source of power as indicated by the legend at the input socket on the rear of the instrument. Use the power cord provided. While instruments are normally supplied for 115-volt operation, the power transformer can be reconnected for 230-volt service (see schematic diagram, Figure). When changing connections, be sure to replace line fuses with those of current rating for the new input voltage (refer to Parts List). Make sure that the legend indicates the new input voltage. On instruments changed from 230 to 115 volts, re-

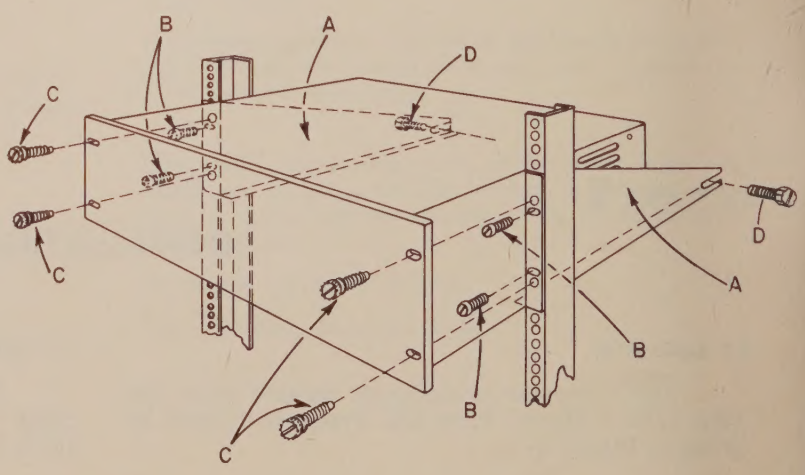


Figure 2-2. Installation of relay-rack model, Type 1133-AR.

move the 230-v nameplate; a 115-v legend is marked beneath. For instruments changed to 230 volts, a nameplate may be ordered.

Connect the OUTPUT of the converter to the input of the counter using the short patch cord provided. Connect the 5 MC OUTPUT at the rear of the counter to the 5 MC INPUT at the rear of the converter; use the long patch cord provided.

NOTE

After initial warmup, the MIXER BALANCE should be adjusted as described in paragraph 3.9.

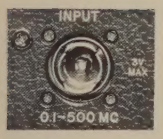
SECTION **3**

OPERATING PROCEDURE

3.1 CONTROLS, CONNECTORS, AND INDICATORS.

The following table lists the controls, connectors, and indicators on the Type 1133-A Frequency Converter.

A 2-position toggle switch is used to turn the instrument on or OFF.

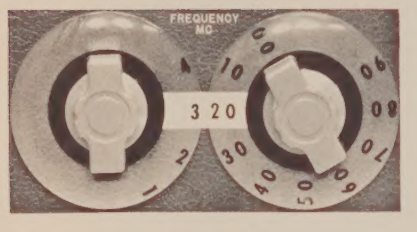


The INPUT connector on the front panel is a Type 874 Coaxial Connector and is used to connect the signal to be measured.

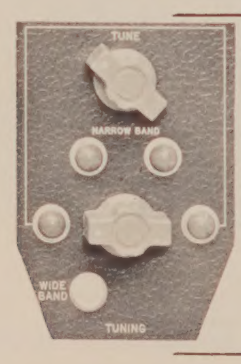
The SENSITIVITY control adjusts the attenuation of the input signal, in 10-db steps.

This continous rotary control adjusts the output voltage of the converter.

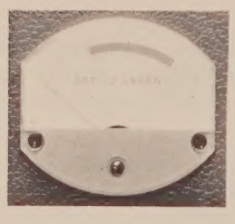
The OUTPUT connector on the panel is used to connect to the input of the Type 1130-A Digital Time and Frequency Meter. It is a Type 874 Coaxial Connector.



This control consists of two rotary switches, each with its own dial. It is used to select the heterodyne reference frequency to be added to the counter reading. The 100's control (at the left) selects the 100's reference frequency, and the 10's control (at the right) selects the 10's reference frequency.

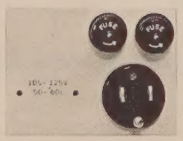


This assembly, consisting of a continuous rotary control, a 5-position rotary switch, and five indicator lights, is used to control the tuned amplifier. The lower (TUNING) knob switches the amplifier in (NARROW BAND) or out (WIDE BAND) and selects the amplifier range. The upper (TUNE) knob adjusts the tuning capacitor of the amplifier and it is used only with the TUNING control in a NARROW BAND position. For NARROW BAND operation, the TUNING control is set to whichever indicator light glows after this control is switched away from the WIDE BAND position. The TUNE control is then used to peak the output voltage.



The meter indicates the output voltage of the converter. The green portion of the scale indicates the output to be used for proper operation of the Type 1130-A Digital Time and Frequency Meter.

This Type 874 Coaxial Connector is located at the rear of the instrument. It is used to connect the 5-Mc output signal of the Type 1130-A Digital Time and Frequency Meter.



A three-terminal male connector, at the rear of the instrument, is for connection to the power source. Two fuse holders are located above the connector, as shown.

3.2 COUNTER CONTROL SETTINGS.

Set the controls of the Type 1130-A Digital Time and Frequency Meter as follows:

MEASUREMENT	--- FREQ
FREQUENCY	--- MC/0.001
DISPLAY	--- INTERMITTENT
DISPLAY TIME	--- MIN
SLOPE	--- - DC or AC
TRIGGER LEVEL	--- vertical
ATTENUATION	--- X1
COMMON-SEPARATE	--- SEPARATE

The above settings are given as a guide to enable the operator to make a quick measurement. The FREQUENCY control setting can be varied to increase the precision of measurement. The DISPLAY TIME can be varied or CONTINUOUS display can be used. For further information on the operation of the counter, see the Operating Instructions for the Type 1130-A Digital Time and Frequency Meter.

3.3 MEASUREMENT OF AN APPROXIMATELY KNOWN FREQUENCY.

Apply the unknown signal to the INPUT connector. This signal should be less than 5 volts rms in amplitude to avoid damaging the input attenuator. Set the TUNING control to WIDE BAND and the OUTPUT control fully clockwise. Set the FREQUENCY controls to the nearest frequency below the unknown frequency. Adjust the SENSITIVITY control to produce a near full-scale reading on the meter and set the pointer in the green region by means of the OUTPUT control. The counter will then indicate the difference between the input frequency and the setting of the FREQUENCY controls.

For example, if the unknown frequency is between 330 and 340 Mc, say 333.333 Mc, set the FREQUENCY controls to 330 Mc. The counter then reads 3.333 Mc. Add the counter reading to the FREQUENCY setting to obtain the unknown frequency.

As a check on the measurement, set the frequency controls 10 Mc higher. The counter then reads the difference between the FREQUENCY setting and the input frequency. Subtracting the counter reading from the FREQUENCY setting should yield the same answer as before. In the example above, setting the FREQUENCY controls to 340 Mc will produce a counter reading of 6.667 Mc -- 340 Mc minus 6.667 Mc equals 333.333 Mc, the input frequency.*

*This check procedure cannot be used for input signals between 200 and 204 Mc, 300 and 304 Mc, 400 and 404 Mc. Refer to paragraph 4.8.4.

If the input signal has insufficient amplitude to produce a reading in the green region of the meter scale, even with the SENSITIVITY and OUTPUT controls fully clockwise, move the TUNING control away from the WIDE BAND position and set it to whichever NARROW BAND light glows. Peak the output voltage with the TUNE control and set the amplitude as before, using the SENSITIVITY and OUTPUT controls.

3.4 MEASUREMENT OF A COMPLETELY UNKNOWN FREQUENCY.

For those rare instances when the frequency of the input signal is completely unknown, a search procedure must be used. With the TUNING control at WIDE BAND and the SENSITIVITY and OUTPUT controls fully clockwise, set the FREQUENCY controls sequentially to 00, 10, 20, 30, --- 100, 110, 120, --- etc. until a meter deflection occurs. Measure and check the answer as described above. If the answer does not check, a spurious response exists and the search should be continued. Because of the wide range of the SENSITIVITY control, it is possible for large-amplitude input signals to produce low-level spurious responses which can cause appreciable meter deflections. Search through the entire frequency range and select the largest response that occurs; reduce the SENSITIVITY control setting whenever a large response is found. Ignore responses smaller than the largest. Start the search at the lowest frequency to minimize the possibility of measuring harmonics of the input signal. When in doubt, use the check procedure described above.

3.5 ZERO-BEAT OPERATION.

For input frequencies slightly above a multiple of 10 Mc, set the FREQUENCY controls to produce a counter reading greater than 10 Mc. For example, if the input frequency is 70.01 Mc, set the FREQUENCY controls to 60 Mc, producing a counter reading of 10.01 Mc. A setting of 70 Mc would leave a beat frequency of 10 kc--too low in frequency to pass through the output amplifier. To check the above example, set the FREQUENCY controls to 80 Mc and read a difference frequency of 9.99 Mc, 80 Mc minus 70.01 Mc. This procedure need only be used for input frequencies within 100 kc of an integral multiple of 10 Mc.

3.6 TUNING.

To increase the sensitivity of the instrument and combat noise and extraneous signals which may exist along with the desired input signal, a tuned amplifier can be switched into the measuring system. With input frequencies from 10 to 500 Mc, the amplifier covers the range from 10 to 200 Mc (see Princi-

ples of Operation, Section 4, page 8.) The amplifier is operated by two controls. The TUNING control switches the amplifier out (WIDE BAND) or in (NARROW BAND), and selects one of the four coils necessary to cover the 20-to-1 range. The TUNE control adjusts the tuning capacitor of the amplifier. The positions of the TUNING control corresponding to the amplifier coils are indicated by lights. With the TUNING control in the WIDE BAND position, the WIDE BAND indicator light will glow. With the TUNING control in any NARROW BAND position, one indicator light will glow showing the proper position of the control. The indicator lights are controlled by the settings of the FREQUENCY controls. For example, with the FREQUENCY controls set to 330 Mc, the second NARROW BAND indicator light will glow (if the TUNING control is set to a NARROW BAND position), showing that the 20- to 40-Mc coil of the tuned amplifier should be used. For certain positions of the FREQUENCY controls (00, 200, 300, 400) the WIDE BAND indicator light will remain on when the TUNING control is moved, indicating that the tuned amplifier cannot be used. For these positions, however, the gain of the output amplifier is increased so that no loss in sensitivity occurs.

In addition to increasing the sensitivity of the instrument because of its gain, the tuned amplifier also provides selectivity to guard against noise and extraneous signals which may exist within the ±10-Mc conversion band centered on the heterodyne reference frequency. Figure 3-1 shows a typical plot of the bandwidth versus frequency of the tuned amplifier.

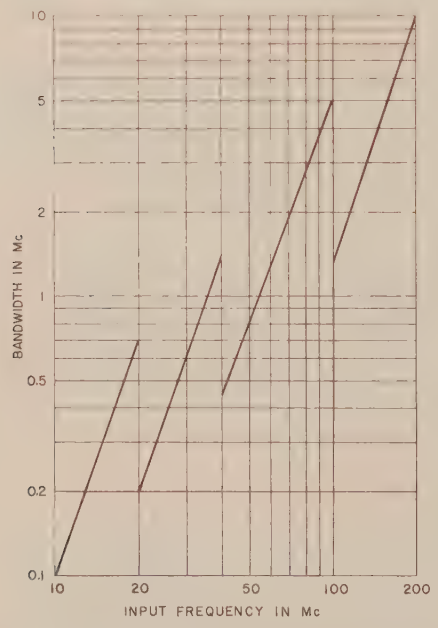


Figure 3-1. Tuned-amplifier bandwidth versus frequency. For input frequencies above 200 Mc, the amplifier operates from 10 to 100 Mc.

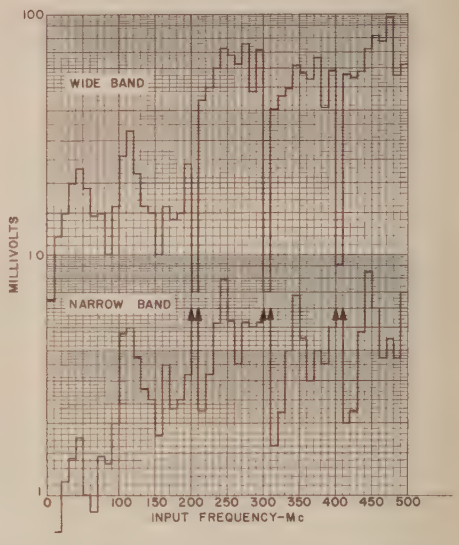


Figure 3-2. Typical over-all sensitivity of converter and counter for 10.1-Mc counter indication. This is the worst case. The sensitivity is better for lower frequencies of the converter output.

3.7 SENSITIVITY.

The sensitivity figures listed in the instrument specifications are broad, all-inclusive figures. Figure 3-2 shows a plot of the sensitivity versus frequency of a typical instrument for both WIDE BAND and NARROW BAND operation. This plot was taken for a beat-frequency output of 10.1 Mc, where the sensitivity of the associated counter is poorest. Therefore the plot is labeled "Worst-Case Sensitivity." For operation at output beat frequencies lower than 10.1 Mc, the sensitivity is significantly better.

The green region of the panel meter must accommodate the worst conditions of operation over the entire frequency and amplitude ranges of the converter. Over most of the range, correct results will be obtained with the pointer below, in, or above the green region. The counter used with the converter is also an indicator of proper operation. In general, a steady reading of the counter indicates a correct measurement, while an erratic, inconsistent reading indicates an incorrect measurement.

NOTE

To obtain the best sensitivity, the TRIGGER LEVEL control of the counter must be adjusted for optimum sensitivity. When working with extremely low-level signals, adjust the TRIGGER LEVEL for the steadiest reading and check the measurement.

3.8 ACCURACY.

The accuracy and stability of the Type 1133-A Frequency Converter is equal to that of the 5-Mc driving source, e.g., $3/10^8$ per week, using the Type 1130-P4 Precision Time-Base Oscillator. For extreme accuracy, a 5-Mc frequency standard, such as the General Radio Type 1113-A Standard-Frequency Oscillator, can be used.

3.9 MIXER BALANCE.

As described under Principles of Operation, Section 4, measurements between 10 and 20, 210 and 220, 310 and 320, 410 and 420 Mc involve the use of a special double-balanced mixer circuit. After shipment or prolonged operation, the balance of the circuit may need readjustment. To adjust the circuit, proceed as follows:

Set the TUNING control to WIDE BAND. Remove any input signal and turn the SENSITIVITY and OUTPUT controls fully clockwise. Set the FREQUENCY controls to 10 Mc. Remove the screw labeled MIXER BALANCE from the front panel and adjust the uncovered potentiometer with a small screwdriver to obtain a null on the panel meter.*

NOTE

The above adjustment is only necessary for frequency measurements between 10 and 20, 210 and 220, 310 and 320, 410 and 420 Mc.

3.10 EXTENDED-RANGE OPERATION.

For operation beyond 500 Mc, use can sometimes be made of other modulation products generated in the first mixer of the converter. For example, a large-amplitude signal, with a frequency of 875 Mc, can be measured by setting the FREQUENCY controls to 470 Mc. The 875-Mc signal beats with the second harmonic of the 400-Mc hundreds-reference signal in the first mixer, leaving a difference frequency of 75 Mc to beat with the 70-Mc tens-reference signal in the second mixer. The counter reads the 5-Mc output frequency. In this example the sum of the tens reference frequency and the counter reading is added to the proper harmonic of the hundreds reference frequency to produce the answer. In other cases, the sum of the tens reference frequency and the counter reading is subtracted from the hundreds reference harmonic. An example illustrating this is an input frequency of 576 Mc. If the hundreds reference control is set to 2 or 3, the input signal will beat with the 600-Mc harmonic, leaving a difference frequency of 24 Mc. Setting the tens reference control to 20 produces a counter reading of 4 Mc. Subtracting the 24 Mc from 600 Mc gives 576 Mc, the input frequency.

The following table lists the settings of the hundreds reference control for this type of operation. The third column indicates whether the sum of the tens reference frequency and the counter reading is to be added to or subtracted from the hundreds reference harmonic.

TABLE 3-1. REFERENCE FREQUENCIES FOR EXTENDED-RANGE OPERATION.

Input Frequency	Hundreds-Reference Frequency	Add/Subtract
500-600 Mc	200 or 300	Subtract
600-700	200 or 300	Add
700-800	200 or 400	Subtract
800-900	200 or 400	Add
900-1000	200	Subtract
	300	Add

The above type of operation comes under the heading of "tricks" and is not a recommended procedure. There are times, however, when it is very useful.

*For a more precise method of adjustment, see paragraph 5.6.3.

SECTION 4

PRINCIPLES OF OPERATION

4.1 GENERAL.

Figure 4-1 shows an over-all block diagram of the Type 1133-A Frequency Converter. Input signals are passed first through the attenuator (controlled by the SENSITIVITY control) and then through a 100-Mc-wide band-pass filter selected by the hundreds reference FREQUENCY control. Signals below 200 Mc are routed to the 2nd mixer, either directly or through the tuned amplifier. In the 2nd mixer the input signal is heterodyned against the tens reference frequency (from 10 to 190 Mc, depending on the setting of the FREQUENCY controls); the beat-frequency output of the mixer is passed to the video amplifier where it is amplified, metered, and applied to the output. The OUTPUT control varies the gain of the video amplifier to set the output level.

Input signals above 200 Mc are heterodyned against the hundreds reference frequency (200, 300, or 400 Mc) in the 1st mixer. The 0- to 100-Mc beat-frequency output of the 1st mixer is filtered and then is processed exactly like an input signal below 200 Mc. If the signal applied to the 2nd mixer is below 10 Mc (input frequencies of 0-10, 200-210, 300-310, 400-410 Mc), the 2nd mixer is converted to an amplifier and the gain of the video amplifier is increased. In such cases the tuned amplifier cannot be used (since it operates only from 10 to 200 Mc) and the WIDE BAND indicator light remains on.

4.2 TENS REFERENCE-FREQUENCY GENERATOR.

Figure 4-2 shows a block diagram of the tens reference-frequency generator. The output signals of the generator are well filtered and then pass to the tens frequency selector. To produce reference frequencies from 100 to 190 Mc, the tens selector mixes signals as shown in Figure 4-3 and Table 4-1. The

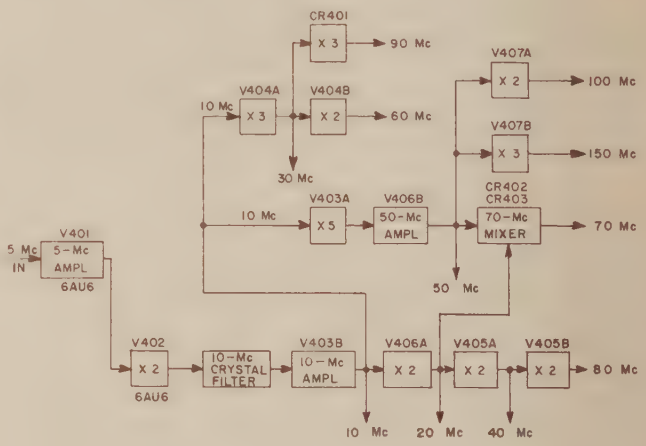


Figure 4-2. Block diagram of the 10's reference-frequency generator.

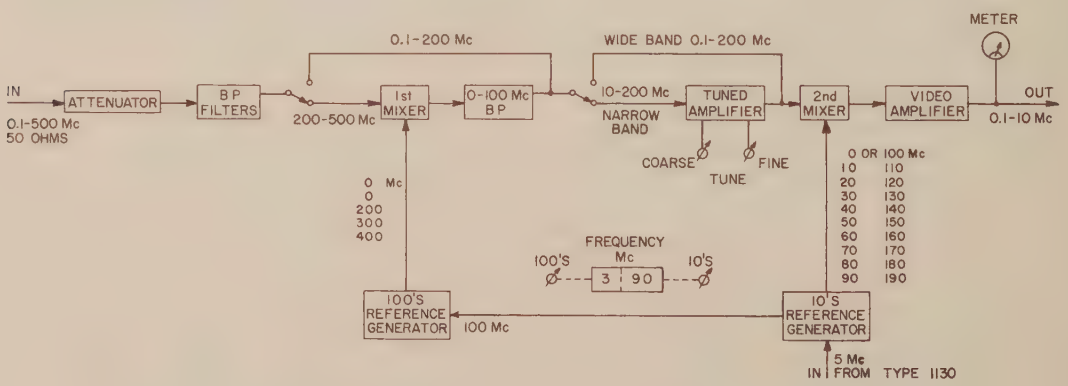


Figure 4-1. Over-all block diagram. A single conversion system is used below 200 Mc; a double conversion system from 200 to 500 Mc.

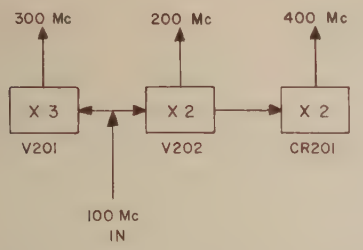


Figure 4-3. Simplified schematic of the 100- to 190-Mc generator.

TABLE 4-1. REFERENCE-FREQUENCY COMPONENTS FOR 100- TO 190-MC RANGE.

Reference Frequency	Components
100 Mc	80 + 20
110	80 + 30
120	80 + 40
130	80 + 50
140	80 + 60
150	150
160	80 + 80
170	150 + 20
180	150 + 30
190	150 + 40

reference signals are passed to the hundreds frequency selector. With the hundreds selector at 0, 2, 3, or 4, reference signals from 0 to 90 Mc, as selected by the tens selector, are applied to the 2nd mixer. With the hundreds selector at 1, reference signals from 100 to 190 Mc are applied to the 2nd mixer.

4.3 HUNDREDS REFERENCE-FREQUENCY GENERATOR.

Figure 4-4 shows a block diagram of the hundreds reference-frequency generator. The 100-Mc output of the tens generator is applied to a push-push doubler to produce a frequency of 200 Mc and to a push-pull tripler to produce a frequency of 300 Mc. To ensure signal purity, the cathode return circuits are switched to shut off the tripler when the doubler is operating, and vice versa. The 200-Mc output of the doubler is applied to a germanium-diode doubler to produce a frequency of 400 Mc. The output signals are applied to the hundreds reference-frequency selector.

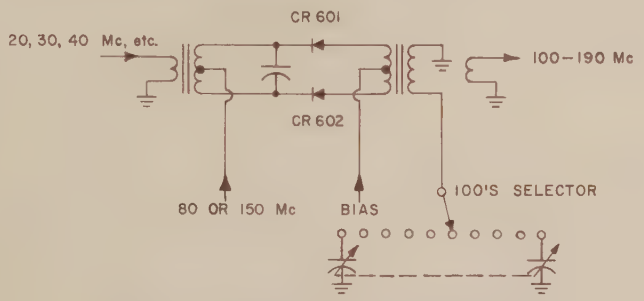


Figure 4-4. Block diagram of the 100's reference-frequency generator.

4.4 HUNDREDS FREQUENCY SELECTOR AND 1ST MIXER.

Figure 4-5 shows a block diagram of the hundreds frequency selector. The input signal is routed through the attenuator and is applied to a band-pass filter selected by the hundreds frequency selector. Signals below 200 Mc are passed through the appropriate filter and are applied directly to the 2nd mixer. Signals above 200 Mc are applied to the 1st mixer and are heterodyned with 200, 300, or 400 Mc. The output of the mixer is passed through a 0- to 100-Mc low-pass filter and is applied to the 2nd mixer. The 1st Mixer crystal is a Type 1N21-C, which can be easily replaced in the event of a burnout.

4.5 TUNED AMPLIFIER.

Signals can be applied to the 2nd mixer either directly or through the tuned amplifier. Figure 4-6 shows a simplified schematic diagram of the ampli-

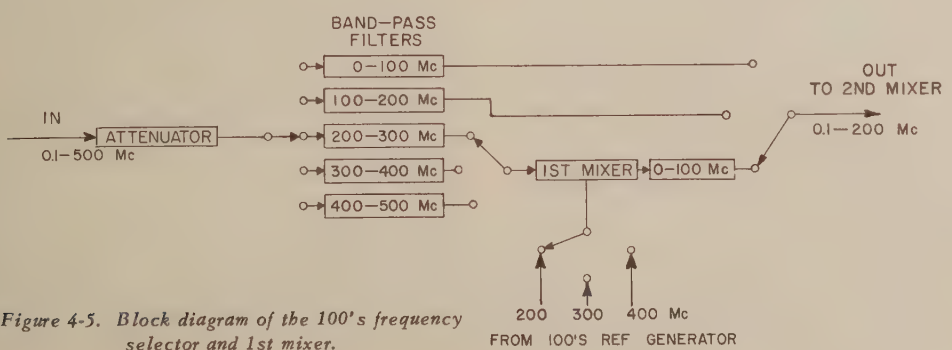


Figure 4-5. Block diagram of the 100's frequency selector and 1st mixer.

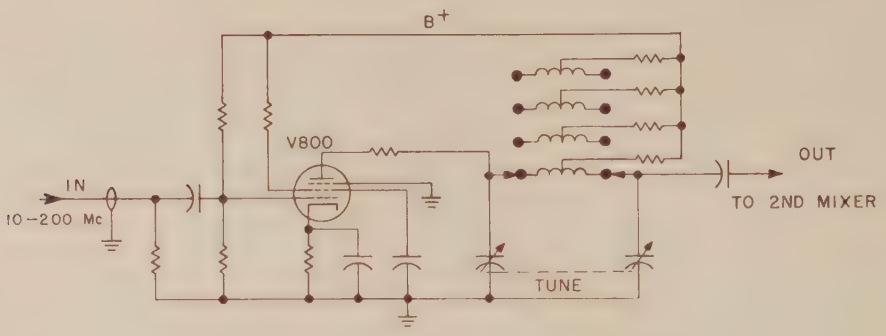


Figure 4-6. Simplified schematic of the tuned amplifier.

fier. The TUNING control routes the signal either directly to the 2nd mixer (WIDE BAND) or to the grid of tube V800, a high gain pentode (NARROW BAND). The TUNING control also selects the appropriate one of four amplifier coils, which cover the following respective ranges: 10-20, 20-40, 40-100, and 100-200 Mc. The positions corresponding to these coils are marked by indicator lights which are controlled by both the TUNING and the FREQUENCY controls. The TUNE control adjusts the tuning capacitor of the amplifier. The amplifier has a gain of about ten; its bandwidth versus frequency is shown in Figure 3-1.

4.6 2ND MIXER.

Figure 4-7 shows a simplified schematic diagram of the special double-balanced 2nd mixer circuit.* For input frequencies between 10 and 20 Mc, both the reference frequency and the input-signal frequency must be suppressed in the mixer output.

An input frequency of 11 Mc, for example, would be heterodyned in the mixer with a reference frequency of 10 Mc. Since the counter may be sensitive to both the 11-Mc signal and the 10-Mc reference, as well as to the 1-Mc beat note, both signal and reference frequencies in the output must be as small as possible. The circuit is balanced by the adjustment of the relative plate currents of the two tubes, to equalize the gains.

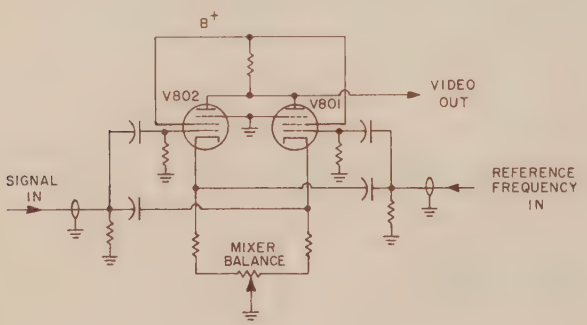


Figure 4-7. Simplified schematic of the 2nd mixer.

*H.T. McAleer, "Mixer Circuit Has Clean Output," ELECTRONIC INDUSTRIES, October, 1960.

4.7 VIDEO AMPLIFIER.

4.7.1 AMPLIFIER. The video amplifier is a conventional three-stage amplifier with a gain of about 300. To achieve the necessary 10-Mc bandwidth, shunt peaking is used in the first two stages and series peaking is employed between the third stage and the output cathode follower. Each amplifier stage has a 68-ohm cathode feedback resistor. At input frequencies of 0-10, 200-210, 300-310, and 400-410 Mc, the 2nd mixer is purposely unbalanced to convert it to an amplifier, and the 68-ohm amplifier cathode resistors are shorted out by capacitors and diodes to increase the amplifier gain to about 1000.

The OUTPUT control varies the gain of the amplifier by adjusting the grid bias of the three stages. The output voltage is rectified by two germanium diodes and is applied to the panel meter through the meter amplifier tube.

NOTE

Because of the finite output impedance of the cathode follower (about 100 ohms), the cable capacitance between the OUTPUT connector and the associated counter must be kept as low as possible to avoid loss of sensitivity at the higher output frequencies; use as short a cable as possible.

4.7.2 DYNAMIC NOTCH FILTER. To ensure linear mixing and to avoid deterioration of the signal-to-noise ratio of an input signal, the mixers of the Type 1133-A Frequency Converter are operated with a

reference-frequency signal of much higher level than the required input signal. Because of this, the mixers are quite sensitive to noise and to spurious signals existing with the reference-frequency signals. The reference frequencies for the 2nd mixer, for example, even though they are well filtered, still contain small sideband signals that are 10 Mc on either side of the desired reference frequency. These sidebands mix with the reference signal in the mixer and produce a small residual 10-Mc output. If the desired output signal is greater than a few hundred kilocycles, the 10-Mc noise causes no difficulty with most counters. For output frequencies below a few hundred kilocycles, however, even a slight amount of 10-Mc noise can cause the input circuits of the counter to generate extra pulses and may produce an erratic frequency reading.

To avoid this difficulty, a nonlinear 10-Mc filter trap* is connected across the output of the video-amplifier cathode follower. This filter removes the 10-Mc noise on a low-frequency output signal, yet passes a desired 10-Mc output signal.

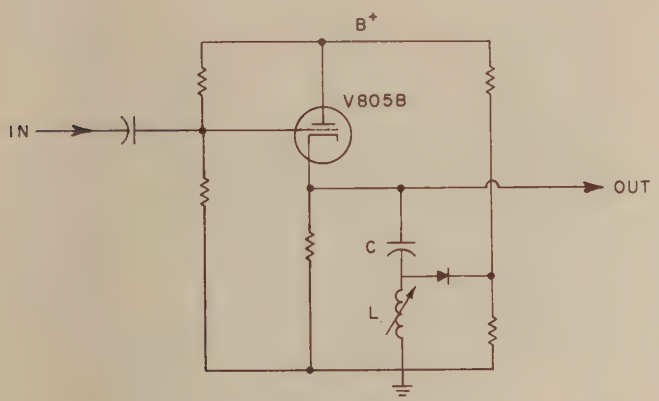


Figure 4-8. Simplified schematic of the dynamic notch filter.

Figure 4-8 shows a simplified schematic diagram of the output cathode follower and notch filter. The series capacitance and inductance connected across the output constitute a series trap, tuned to 10 Mc, that effectively removes any 10-Mc noise from a low-frequency output signal. The diode is normally back-biased by the dc voltage of the voltage divider and does not effect the filtering action. With a large 10-Mc signal, however, the diode begins to conduct, spoils the Q of the inductor, and reduces the efficiency of the notch filter. The diode bias is set so that the 10-Mc residual noise is eliminated, but a 10-Mc signal of sufficient amplitude to operate the counter is passed with little attenuation.

*H.T. McAleer, "Dynamic Notch Filter," ELECTRONIC EQUIPMENT ENGINEERING, August, 1962.

4.8 SPURIOUS RESPONSES.

4.8.1 GENERAL. The design of the Type 1133-A Frequency Converter is similar to that of a wide range radio receiver, and, like a radio receiver, the converter is capable of producing spurious responses. In all cases, these spurious responses are well below the proper response in amplitude, but their presence may cause confusion to the operator.

Spurious responses are caused mainly by image response and harmonic mixing.

4.8.2 IMAGE RESPONSE. Below 200 Mc the conversion band of the converter occupies 10 Mc on each side of the heterodyne reference frequency; the 10-Mc band above the reference frequency is the main band and the 10-Mc band below the reference frequency is the image band. On WIDE BAND operation the converter is equally sensitive to signals in the main band and the image band. With only one signal present in the input, increasing the heterodyne reference frequency from zero ensures that the main response occurs before the image response. In this case the image response can be used to check the measurement.

For example, an input frequency of 82 Mc produces a counter indication of 2 Mc with a heterodyne reference frequency of 80 Mc (main band) and a counter indication of 8 Mc with a heterodyne reference frequency of 90 Mc (image band). Then, (90 Mc minus 8 Mc) equals (80 Mc plus 2 Mc) equals 82 Mc, the input frequency.

With more than one signal present in the conversion band, the tuned amplifier, used in NARROW BAND operation, can aid in suppressing signals in the image band and separating signals in the main band.

Above 200 Mc a dual-conversion system is used in the Type 1133-A Frequency Converter. The first conversion main band covers up to 100 Mc above the hundreds reference frequency; the image band covers down to 100 Mc below the hundreds reference frequency. Band-pass filters before the 1st mixer attenuate the image band except for signals close to the main band. Figure 4-9 shows an example of a spurious response caused by the 1st conversion image response. An input signal of 292 Mc produces a 92-Mc beat with 200 Mc or an 8-Mc beat with 300 Mc in the 1st mixer. With a 90-Mc heterodyne frequency in the 2nd mixer, the proper 92-Mc beat produces a 2-Mc counter indication. With no heterodyne frequency in the 2nd mixer, the 8-Mc image beat produces an 8-Mc counter indication. With a 10-Mc heterodyne frequency in the 2nd mixer, the 8-Mc image beat produces a counter reading of 2 Mc. Thus, we have three frequency readings: 292 Mc, 308 Mc and 312 Mc. Note that both the 292-Mc and the 308-Mc readings apparently check. In WIDE BAND operation the 308-Mc response will be larger than the 292- or

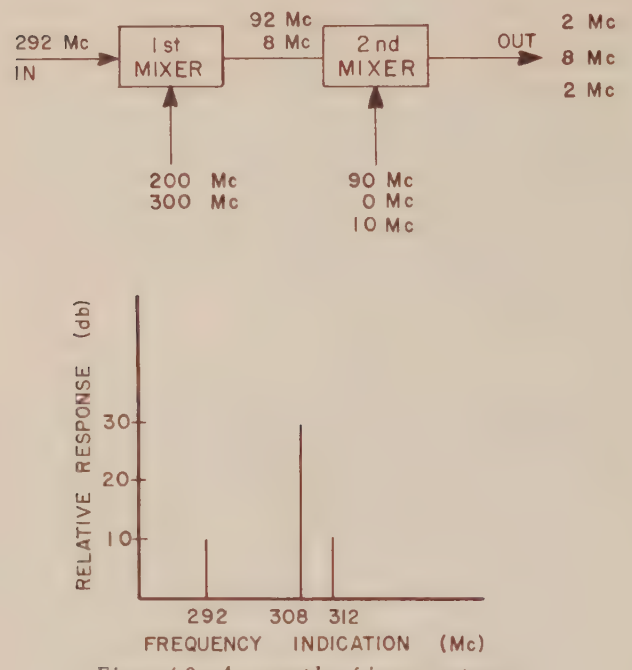


Figure 4-9. An example of image response.

312-Mc response, since the video amplifier gain is higher from 300 to 310 Mc. In this case, however, the first response encountered, i.e. 292 Mc, is the correct response. This behavior occurs for signals just below 200, 300, or 400 Mc.

4.8.3 HARMONIC MIXING. Beats in a mixer can be produced not only between the two input frequencies, but also between various harmonic combinations of the input frequencies. Below 200 Mc the double-balanced mixer in the Type 1133-A Frequency Converter attenuates these spurious harmonic beats at least 40 db below the desired beat. Above 200 Mc the bandpass filters before the 1st mixer attenuate the spurious beats, except in the region near 300 Mc, because of the overlap of the filter characteristics. Figure 4-10 shows an example of a spurious beat caused by harmonic mixing. An input signal of 308 Mc produces a 92-Mc beat with the second harmonic of 200 Mc or an 8-Mc beat with 300 Mc in the 1st mixer. The spurious 92-Mc beat produces a 2-Mc counter indication with a heterodyne frequency of 90 Mc in the 2nd mixer. The proper 8-Mc beat produces a 2-Mc counter indication with a heterodyne frequency of 10 Mc in the 2nd mixer. Thus we have three frequency readings: 292, 308, and 312 Mc, exactly as in the example above. In this case, however, the first response, 292 Mc, is not correct. How can one tell the difference? The difference lies in the relative amplitude of the 292-Mc and the 312-Mc responses. The 312-Mc response will be at least 10 db higher. (Note: Each position of the SENSITIVITY control corresponds to a 10-db change in attenuation.)

The rule, therefore, for the measurement of unknown frequencies in the vicinity of 300 Mc is: If two pairs of responses occur, use the lower frequency pair unless the smaller response of the higher frequency pair is much greater than the smaller response of the lower frequency pair.

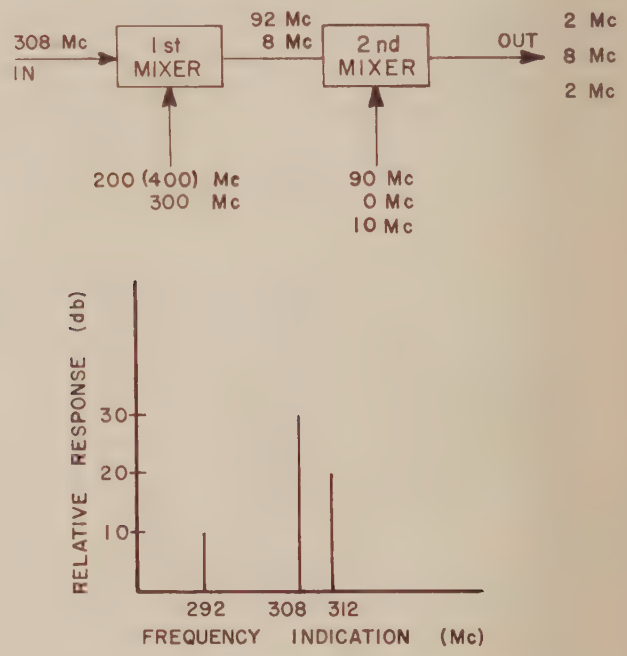


Figure 4-10. An example of harmonic mixing response.

4.8.4 IMAGE CHECK. The method for checking the frequency measurement by the image response, as described in paragraph 3.3, cannot be used with input frequencies between 200 and 204, 300 and 304, and 400 and 404 Mc. The low-frequency beat from the first mixer (0 to 4 Mc) goes directly through the 2nd mixer and appears in the output together with the 10- to 6-Mc image beat. The meter will indicate, but the counter reading will be erratic. This will cause no difficulty, however, since the proper response will be much larger in amplitude than any spurious response.

SECTION **5**

SERVICE AND MAINTENANCE

5.1 GENERAL.

We warrant that each new instrument sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards, after examination by our factory, district office, or authotized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest district office, requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

5.2 REMOVING THE CABINET.

If the instrument is equipped with end frames, remove the four screws that secure them to the front panel. Roll the instrument forward onto its handles. Remove the two screws that secure the cabinet to the main structure and lift the cabinet up and off.

If the instrument is relay-rack mounted with General Radio Type ZSU (3) Brackets, either the cabinet or the instrument can be removed from the rack independently of the other. To remove the cabinet, remove the two screws and washers on the back of the cabinet that secure it to the main structure; on each side of the cabinet; remove the screw that holds it to the bracket, and pull the cabinet back and off. To remove the instrument from the rack, remove the two screws on the back of the cabinet that secure it to the main structure; remove the four panel screws that secure the instrument to the rack, and pull the instrument forward by means of the handles, Support the instrument from underneath before withdrawing it fully. The converter weighs about 34 pounds.

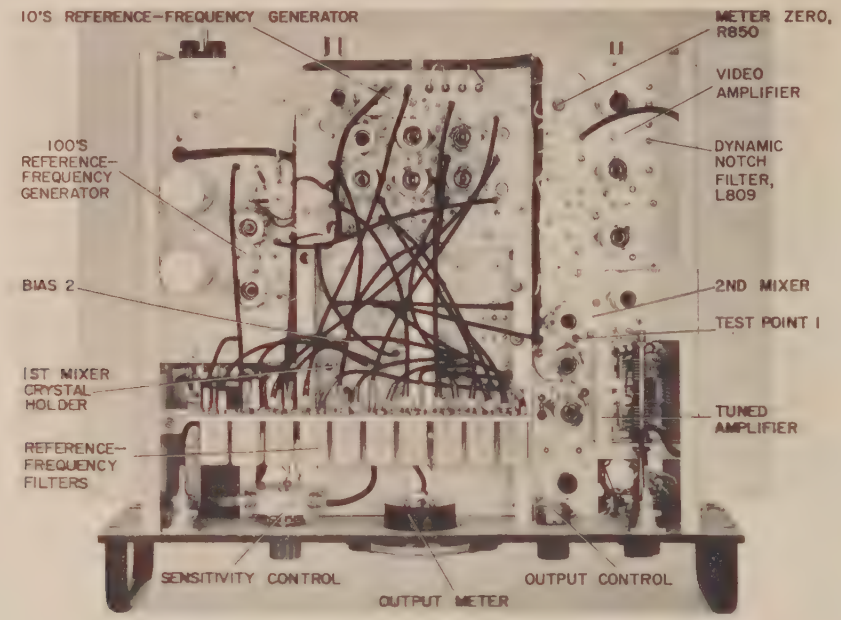


Figure 5-1. Composition of the instrument, top view.

5.3 COMPOSITION OF THE INSTRUMENT.

The Type 1133-A Frequency Converter is composed of 8 major sections:

1) Power Supply
2) 100's Frequency Selector
3) Tuned Amplifier and 2nd Mixer
4) Video Amplifier and Meter Amplifier
5) 10's Reference-Frequency Generator
6) 100's Reference-Frequency Generator
7) Reference-Frequency Filters
8) 10's Frequency Selector

Figures 5-1 and 5-2 show the major sections of the instrument and the location of certain adjustments and test points. The circuits of several of the sections are enclosed by shield covers. To remove these covers, unscrew only the nuts and screws indicated by black circles. Photographs of the sections with shield covers removed are shown with the section schematic diagrams.

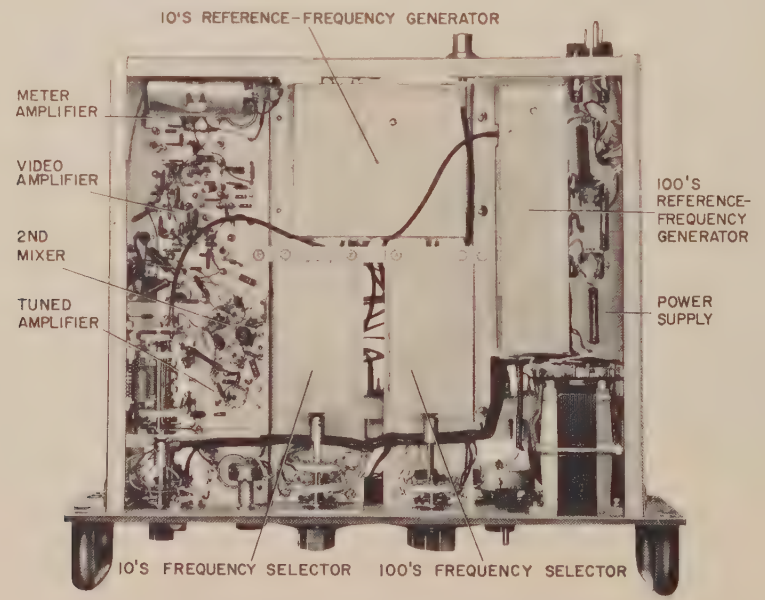


Figure 5-2. Composition of the instrument, bottom view.

5.4 TROUBLE-SHOOTING.

5.4.1 GENERAL. Improper operation of the instrument can occur in any of three forms:

1) Complete failure, i.e., loss of output;
2) Poor sensitivity;
3) Erratic measurements.

5.4.2 NO OUTPUT. Loss of output invariably occurs because of failure of a component, such as a vacuum tube or diode, and not from misadjustment. No adjustments should be made after replacing a component unless the instrument is insensitive or produces erratic measurements.

The following simple tests will help to localize a failure, whereupon reference to the proper schematic diagram will help to locate the trouble precisely.

5.4.2.1 Test 1. Observe the TUNING lamps. If none are glowing, check the input power connection, the fuses, the power switch, the power transformer, and the TUNING lamp bulb.

5.4.2.2 Test 2. Set the FREQUENCY selectors to 10, the TUNING control to WIDE BAND, and the OUTPUT control fully clockwise. Upset the MIXER BALANCE adjustment (accessible from the front panel). The panel meter should indicate upscale, verifying the operation of the video amplifier, meter amplifier, and meter, and the presence of the internal 10-Mc reference frequency. If the panel meter does not indicate, check the 5-Mc INPUT at the rear of the converter. If the 5-Mc signal is present, remove the cable plug from the 5-Mc INPUT jack and plug it into the OUTPUT connector. If the meter then indicates, the meter amplifier and meter are functioning. Remove the cable plug from the OUTPUT connector and plug it into the INPUT jack. Set the FREQUENCY selectors to 00. If the panel meter then indicates, the video amplifier is functioning and the trouble must be in the 5-Mc or 10-Mc stages of the 10's reference-frequency generator (Diagram 5).

5.4.2.3 Test 3. If tests 1 and 2 check properly, restore the MIXER BALANCE (refer to paragraph 5.6.3) and determine which internal reference frequencies are active for the FREQUENCY selector settings at which the failure occurred (refer to paragraph 5.5). Perform the recommended test measurements for each, to determine which reference frequency is at fault.

The presence of reference-frequency drive at the 2nd mixer can be verified by connecting the positive terminal of a dc microammeter between TEST POINT 1 (beside V801, see Figure 5-1) and the negative terminal to the instrument chassis. A current indication, with the input signal removed, indicates the presence of reference-frequency drive.

To check the presence of reference-frequency drive at the 1st mixer, and the performance of the 1st mixer diode (CR301), connect the positive terminal of the microammeter to Anchor Terminal 804 (beside the rear wafer of the TUNING switch, on the underside of the chassis), and connect the BIAS 2 terminal (on top of the 100's FREQUENCY selector switch assembly) to the chassis. Current observed at FREQUENCY selector settings of 200, 300, or 400 Mc indicates that CR301 is functioning. Absence of current at all of these settings indicates that either CR301 is defective (refer to paragraph 5.7) or the 100's reference-frequency generator is inoperative (Diagram 6). Absence of current at one of these settings indicates failure of one of the 100's reference frequencies.

5.4.3 POOR SENSITIVITY. Poor sensitivity at one or more (but not all) settings of the FREQUENCY selectors, with an adequate input signal, indicates insufficient reference-frequency drive to the mixer involved. Refer to paragraph 5.5 to determine the reference frequencies and adjustments. If a vacuum tube is involved, try replacing it. Adjust the tuned circuits only if replacing the tube fails to correct the difficulty. If an adjustment is made, do so at the recommended input frequency and watch for erratic measurements (refer to paragraph 5.4.4).

If the meter indicates in the green region and measurements cannot be made, the loss of sensitivity may be in the associated counter. Check that the counter's TRIGGER LEVEL control is set to zero. To adjust the sensitivity of the counter, refer to the Operating Instructions for the Type 1130-A Digital Time and Frequency Meter, paragraph 4.5.2.7.

5.4.4 ERRATIC MEASUREMENTS. Erratic or unstable measurements of an input signal sufficient to produce a meter indication in the green region may be caused by erratic signals, overdrive, misadjustment of the reference-frequency circuits (paragraph 5.5), or misadjustment of the MIXER BALANCE (paragraph 5.6.3).

5.4.4.1 Erratic Signals. If the frequency of the input signal itself is unstable, the frequency measurement will display this instability.

5.4.4.2 Overdrive. Severe overdrive, caused by high-level input signals, can produce unstable measurements even with a meter indication in the green portion of the scale. Rotating the SENSITIVITY control counterclockwise should reduce the meter indication; if not, a severe overload exists and the input signal must be reduced, either by further rotation of the SENSITIVITY control or by external attentuation.

Unstable measurements may also result from improper setting of the associated counter's TRIG-

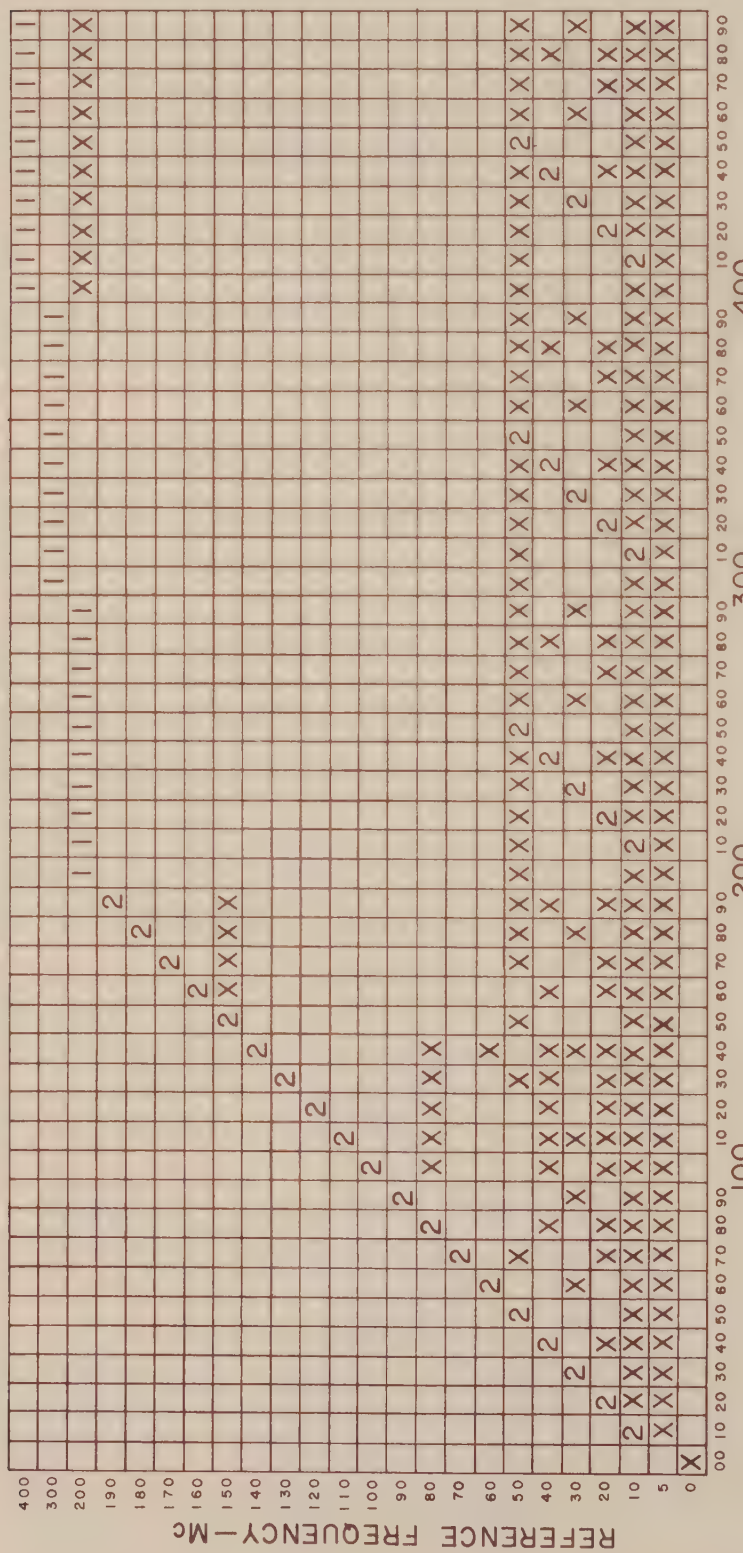


Figure 5-3. Active reference frequencies for each position of the FREQUENCY selector control.

X indicates active reference frequency.
1 indicates reference frequency applied to 1st mixer.
2 indicates reference frequency applied to 2nd mixer.

GER LEVEL control. Set this control for the most stable measurement (usually at 0).

5.5 REFERENCE-FREQUENCY ADJUSTMENT.

From the 5-Mc input signal applied to the rear of the instrument, 22 separate internal reference frequencies are generated. Each of these reference frequencies involves at least one tank circuit or filter. There are 39 clearly marked reference-frequency adjustments. Figure 5-3 shows the reference frequencies active at each position of the FREQUENCY selector controls, and Table 5-1 shows the tubes and adjustments involved.

A different combination of reference frequencies is used for each setting of the FREQUENCY selectors. Therefore, it is a simple matter to determine which, if any, of the reference frequencies is at fault by making several frequency measurements as indicated in the table, using a signal generator or calibrated oscillator.

Need for tube replacement or circuit adjustment will be indicated by improper performance at one or more settings of the FREQUENCY selectors. For example, if the converter operates properly with the FREQUENCY selectors at 00, but not at any other setting, suspect the 5-Mc input frequency or the 5- and 10-Mc reference-frequency circuits. If the instrument fails from 300 to 390 Mc only, suspect the 300-Mc reference frequency. If the instrument fails from 200 to 500 Mc, suspect V407A or the 1st mixer diode, CR301 (refer to paragraph 5.7).

Circuit adjustments may be necessary if erratic measurements occur at any FREQUENCY selector setting other than 00. To determine if adjustments are needed, perform the following test:

Connect the OUTPUT of the converter to an oscilloscope so that the total capacitive loading (cable capacitance plus oscilloscope input capacitance) is about 55 pf. Remove the INPUT signal and set the OUTPUT control fully clockwise. Observe the residual 10-Mc output. If this output is greater than .04 volt peak-to-peak, adjustment is necessary. If an oscilloscope is not available, careful observation of the meter pointer can suffice. If the pointer moves more than its width when the FREQUENCY selectors are changed from 00 to the setting in question, adjustment is necessary.

If the difficulty occurs at the FREQUENCY selector settings of 10, 210, 310 or 410 Mc, adjust the MIXER BALANCE (refer to paragraph 5.6.3). At other FREQUENCY selector settings, adjust the reference-frequency circuits which are active (as shown in Figure 5-3 and Table 5-1). Make the adjustments by applying a signal at the frequency listed under "Input Frequency for Optimum Adjustment" in Table 5-1 and observe, on an oscilloscope, the output signal from the converter. Adjust the various circuits for ade-

TABLE 5-1. REFERENCE-FREQUENCY SOURCES AND ADJUSTMENTS.

Reference Frequency	Source	Tubes and Diodes Involved	Adjustments	Input Test Frequency	Input Frequency For Optimum Adjustment
5 Mc	5 Mc Input	V401	L401, L402	15 Mc	Any
10 Mc	5 V401	V402, V403B	L403,C415, L405, L901	15	219 Mc
20 Mc	10 V403B	V406A	L407, L902	25	170.1
30	10 V403B	V404A	L413, L903	35	180.1
40	20 V406A	V405A	L410, L904	45	190.1
50	10 V403B	V403A, V406B	L404, L406	55	130.1
60	30 V404A	V404B	L415, L905	65	140.1
70	20,50 V406A, V406B	CR403	L408, L409	75	479
80	40 V405A	V405B	L412, L906	85	169
90	30 V404A	CR401	L414, L907	95	299
100	80,20	CR601, CR602	L601,C619	105	109
110	80,30	CR601, CR602	L601,C618	115	119
120	80,40	CR601, CR602	L601,C617	125	129
130	80,50	CR601, CR602	L601,C616	135	139
140	80,60	CR601, CR602	L601,C615	145	149
150	50	V407B	L601,C614, L411, L908	155	159
160	80	CR601, CR602	L601,C613	165	169
170	150,20	CR601, CR602	L601,C612	175	179
180	150,30	CR601, CR602	L601,C611	185	189
190	150,40	CR601, CR602	L601,C610	195	199
200	100 V407A	V202	L416,C206, L203, L909	205	279
300	100 V407A	V201	L416,C206, L910	305	379
400	200	CR201	C213	405	479

TABLE 5-2. OTHER ADJUSTMENTS.

Name	Components To Be Adjusted	Location	Tubes and Diodes Involved	Paragraph Reference	Diagram Reference
Meter Zero	R850	Meter Amplifier	V806	5.6.2	4
Mixer Balance	R820	2nd Mixer	V801, V802	5.6.3	3
Dynamic Notch Filter	L809	Video Amplifier	CR801	5.6.4	4
Peaking Coils	L805, L808	Video Amplifier	V804, V805	5.6.5	4

quate sensitivity with a minimum of noise or amplitude modulation in the output signal. It may be necessary to detune some of the circuits slightly to obtain the best performance. If the difficulty persists, adjust the dynamic notch filter (as noted in paragraph 5.6.4).

5.6 OTHER ADJUSTMENTS.

5.6.1 GENERAL. In addition to the reference-frequency adjustments listed in Table 5-1, a few other adjustments may occasionally be necessary (after replacement of a tube or diode, for example). These adjustments are listed in Table 5-2 and are described in the following paragraphs.

5.6.2 METER ZERO, R850. This adjustment is located in the rear right-hand corner of the instrument (see Figure 5-1). Adjustment is necessary if the meter indication is appreciably off zero, with no connections to the INPUT and OUTPUT and the FREQUENCY selectors at 00. Adjust R850 for zero indication.

5.6.3 MIXER BALANCE, R820. Connect the OUTPUT of the converter to an oscilloscope so that the total capacitive loading is about 55 pf. Remove the INPUT signal and set the OUTPUT control fully clockwise. Set the TUNING control to WIDE BAND and the FREQUENCY selectors to 10 Mc. Observe the residual 10-Mc output. If this output is greater than .04 volt peak-to-peak, remove the MIXER BALANCE screw (at the right of the FREQUENCY selectors) and adjust the exposed screwdriver control for minimum output. If the output cannot be reduced below .04 volt, replace V801 and V802 with a pair of Type 4AU6 tubes that will permit a satisfactory adjustment. Some selection or interchanging of tubes may be necessary.

5.6.4 DYNAMIC NOTCH FILTER, L809. This adjustment is located near the METER ZERO control. Before adjusting it, check the condition of CR801 (Diagram 4) with an ohmmeter and replace it if it is defective. Set the controls as in paragraph 5.6.3 and upset the MIXER BALANCE slightly. Adjust L809 to minimize the residual 10-Mc output. Restore the MIXER BALANCE.

5.6.5 PEAKING COILS, L805, L808. These adjustments are necessary only if the sensitivity of the converter (WIDE BAND) at an output frequency near 10 Mc is abnormally lower than it is at a low output frequency. Normally the instrument should require about twice as much input signal at an output frequency of 10 Mc as at an output frequency of 1 Mc, for the same meter reading. The adjustments, if necessary, should be performed with a sweep-frequency generator (such as the General Radio Type 1025-A). Connect the sweep generator to the INPUT of the converter and observe the OUTPUT on an oscilloscope. Set the FREQUENCY selectors to 00, the TUNING control to WIDE BAND, and the SENSITIVITY and OUTPUT controls fully clockwise. Apply an input signal of about 10 mv with the frequency swept between 5 and 12 Mc. Adjust L805 and L808 for maximum output and flattest response. If a sharp notch occurs near 10 Mc, check CR801.

5.7 REPLACING THE 1ST MIXER DIODE, CR301.

The 1st mixer diode, Type 1N23C, is housed in a cartridge holder located at the top of the 100's FREQUENCY selector switch. The holder can be unscrewed and the crystal replaced. Figure 5-4 shows an exploded view of the holder. When replacing the holder, be sure the threads are properly engaged.

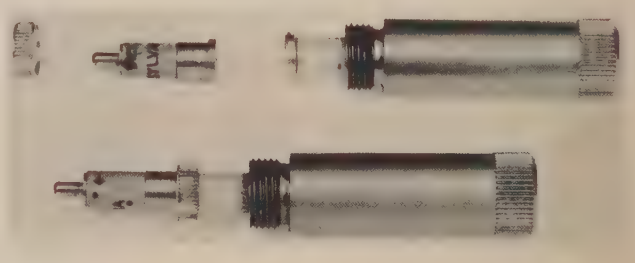


Figure 5-4. Crystal holder for 1st mixer diode.

PARTS LISTS AND SCHEMATICS

On the following pages appear parts lists, schematic diagrams, resistance tables, and photographs, which should prove helpful in trouble-shooting. These are arranged by section as follows:

Diagram No.	Section	Pages
1.	Power Supply	20-21
2.	Input Attenuator and 100's Frequency Selector	22-23
3.	Tuned Amplifier and 2nd Mixer	24-25
4.	Video Amplifier and Meter Amplifier	26-27
5.	10's Reference-Frequency Generator	28-29
6.	100's Reference-Frequency Generator	30-31
7.	Reference-Frequency Filters	32-33
8.	10's Frequency Selector	34-35
9.	Rotary-switch Detail	36

NOTES FOR RESISTANCE TABLES

For all sections, the resistances are measured between the point in question and chassis ground. Set the FREQUENCY selectors to 010, the TUNING control to any NARROW BAND position, and the OUTPUT control fully clockwise. Measurements should be made with the power cord disconnected and the +150-v supply connected to ground.

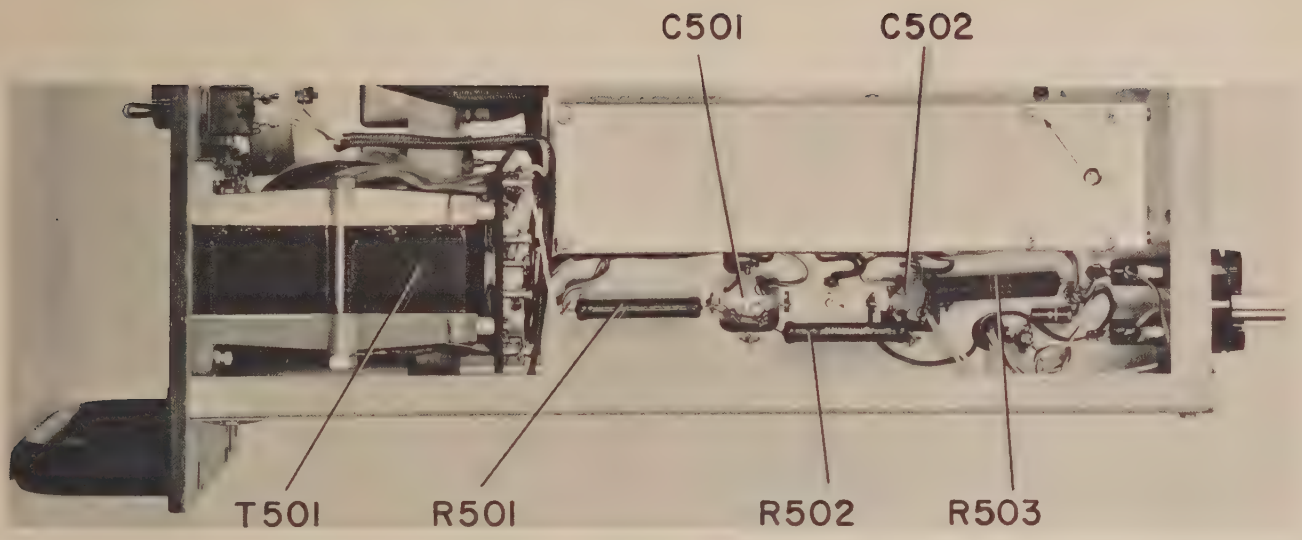


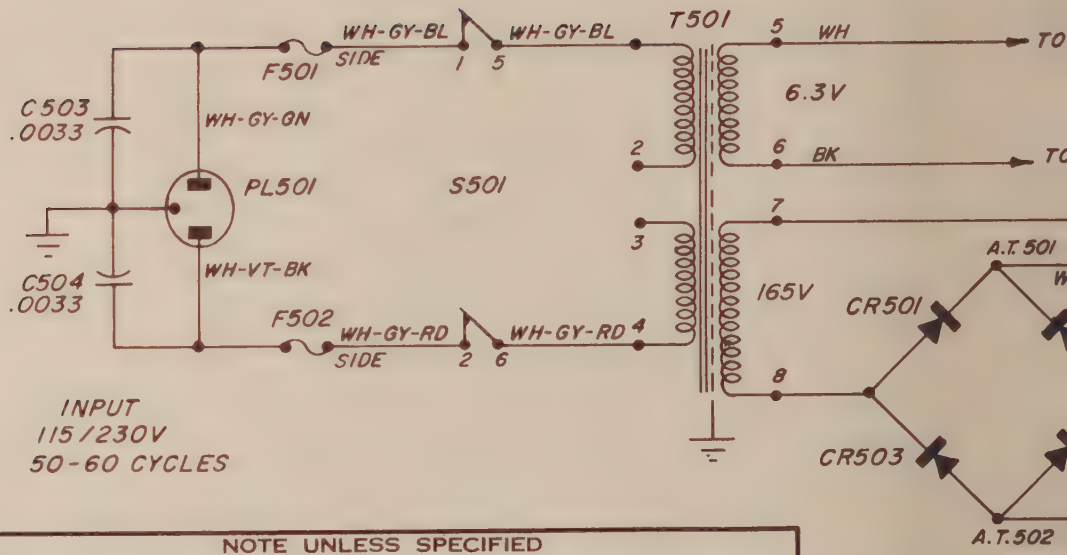
Figure 5-5. Power Supply.

PARTS LIST

REF NO.	RESISTORS	PART NO.
R501	Power, 200Ω ±5% 10w	6670-1205
R502	Power, 200Ω ±5% 10w	6670-1205
R503	Power, 450Ω ±5% 10w	6670-1455
R504	Composition, 30kΩ ±5% 1w	6110-3305
R505	Composition, 240Ω ±5%	6100-1245
	CAPACITORS	
C501A	Electrolytic, 90μf +100-10% 300dcwv	4450-3400
C501B	Electrolytic, 30μf +100-10% 300dcwv	4450-3400
C501C	Electrolytic, 30μf +100-10% 300dcwv	4450-3400
C502A	Electrolytic, 90μf +100-10% 300dcwv	4450-3400
C502B	Electrolytic, 30μf +100-10% 300dcwv	4450-3400
C502C	Electrolytic, 30μf +100-10% 300dcwv	4450-3400
C503	Ceramic, 0.0033μf ±20% 500dcwv	4406-2339
C504	Ceramic, 0.0033μf ±20% 500dcwv	4406-2339
	DIODES	
CR501 thru CR504	1N1694	6082-1014

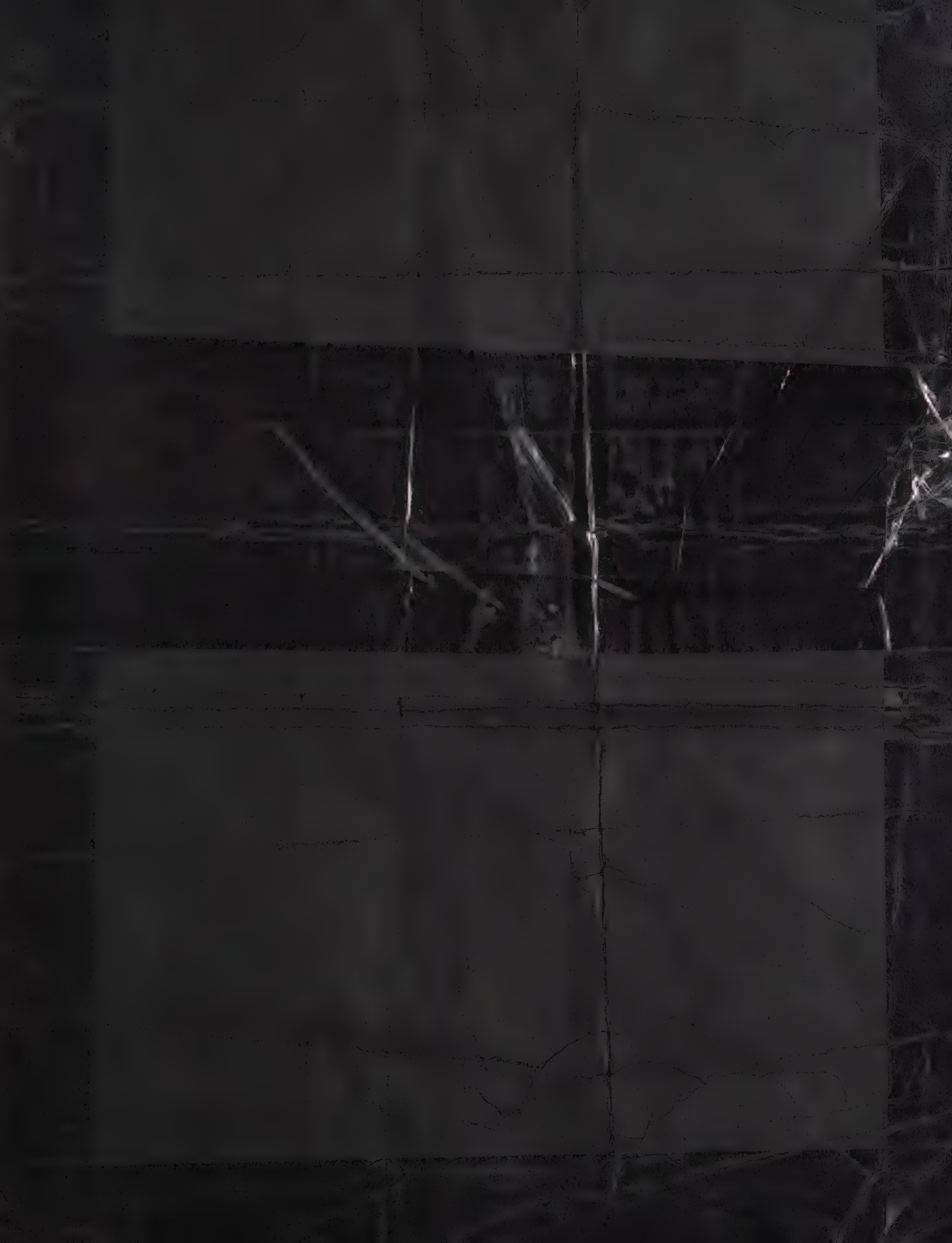
REF NO.	FUSES	PART NO.
F501	115-v, 1a	5330-1400
	230-v, .5a	5330-1000
F502	115-v, 1a	5330-1400
	230-v, .5a	5330-1000
	PLUGS	
PL501		4240-0700
	SWITCHES	
S501		7910-1300
	TRANSFORMERS	
T501		0365-4002

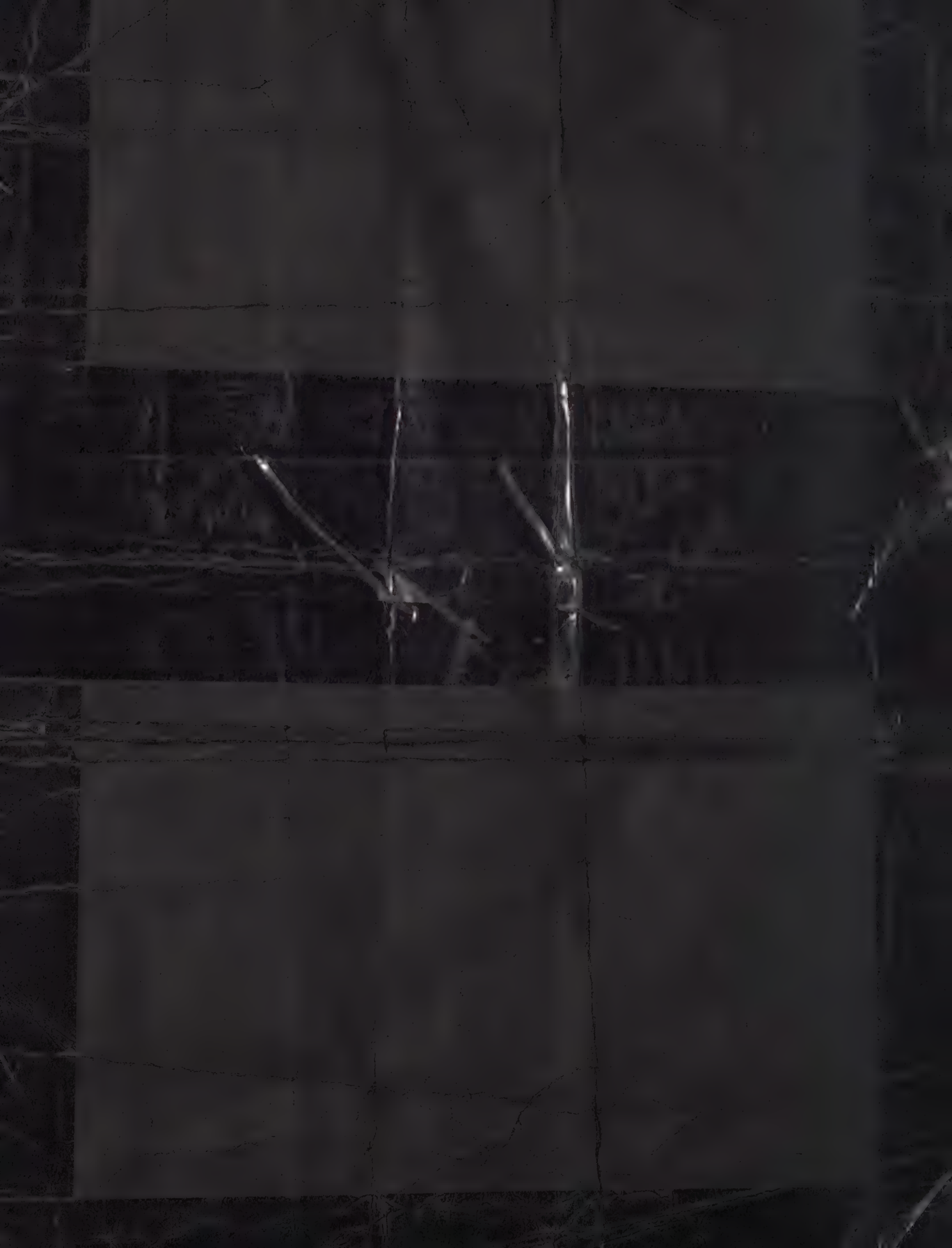
NOTE: FOR T501 OPERATION
FOR 115V OPERATION, CONNECT
1 TO 3 & 2 TO 4
F501 & F502 = 1 AMP
FOR 230V OPERATION, CONNECT
2 TO 3
F501 & F502 = 0.5 AMP



NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/2 WATT.
5. RESISTANCE IN OHMS K = 1000 OHMS M = 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT = ANCHOR TERMINAL
10. TP = TEST POINT





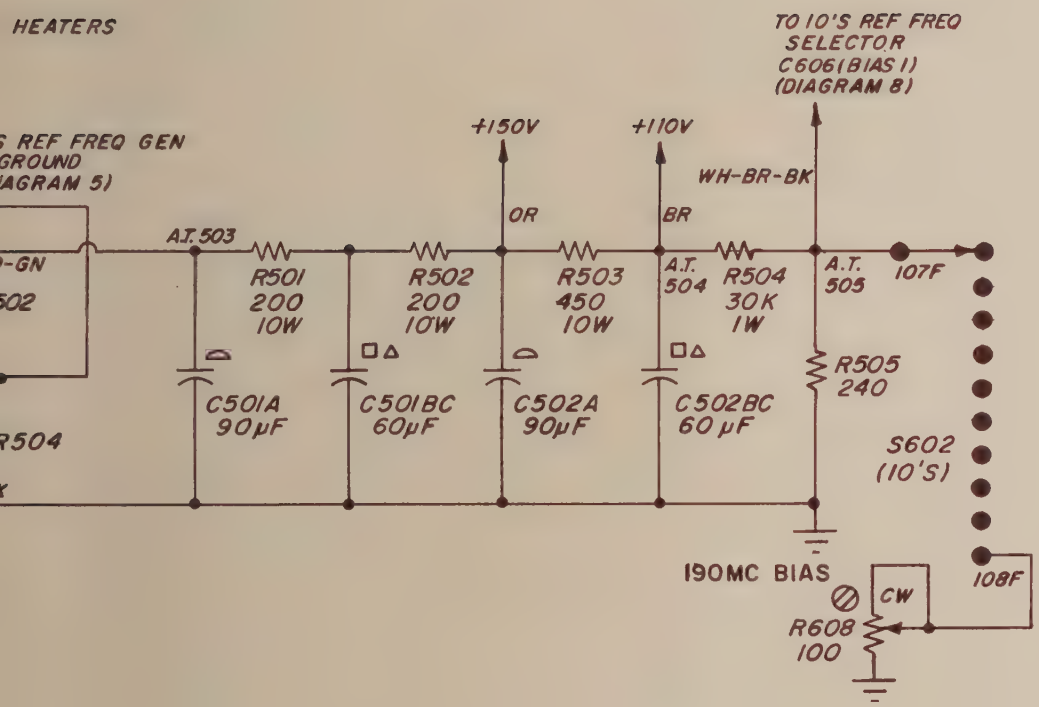


Diagram 1. Power Supply.

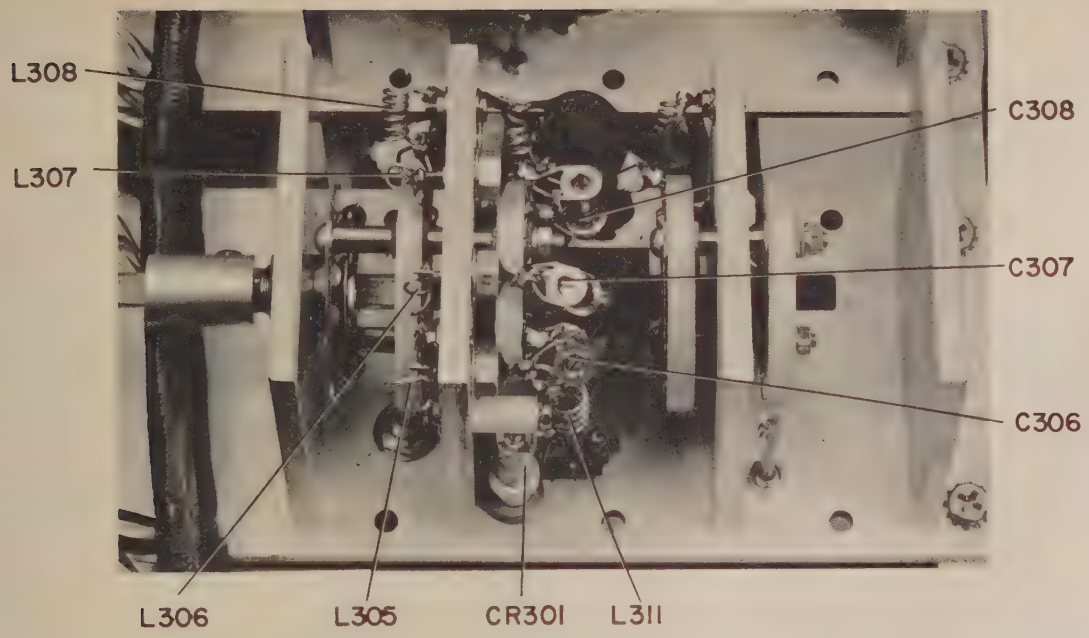
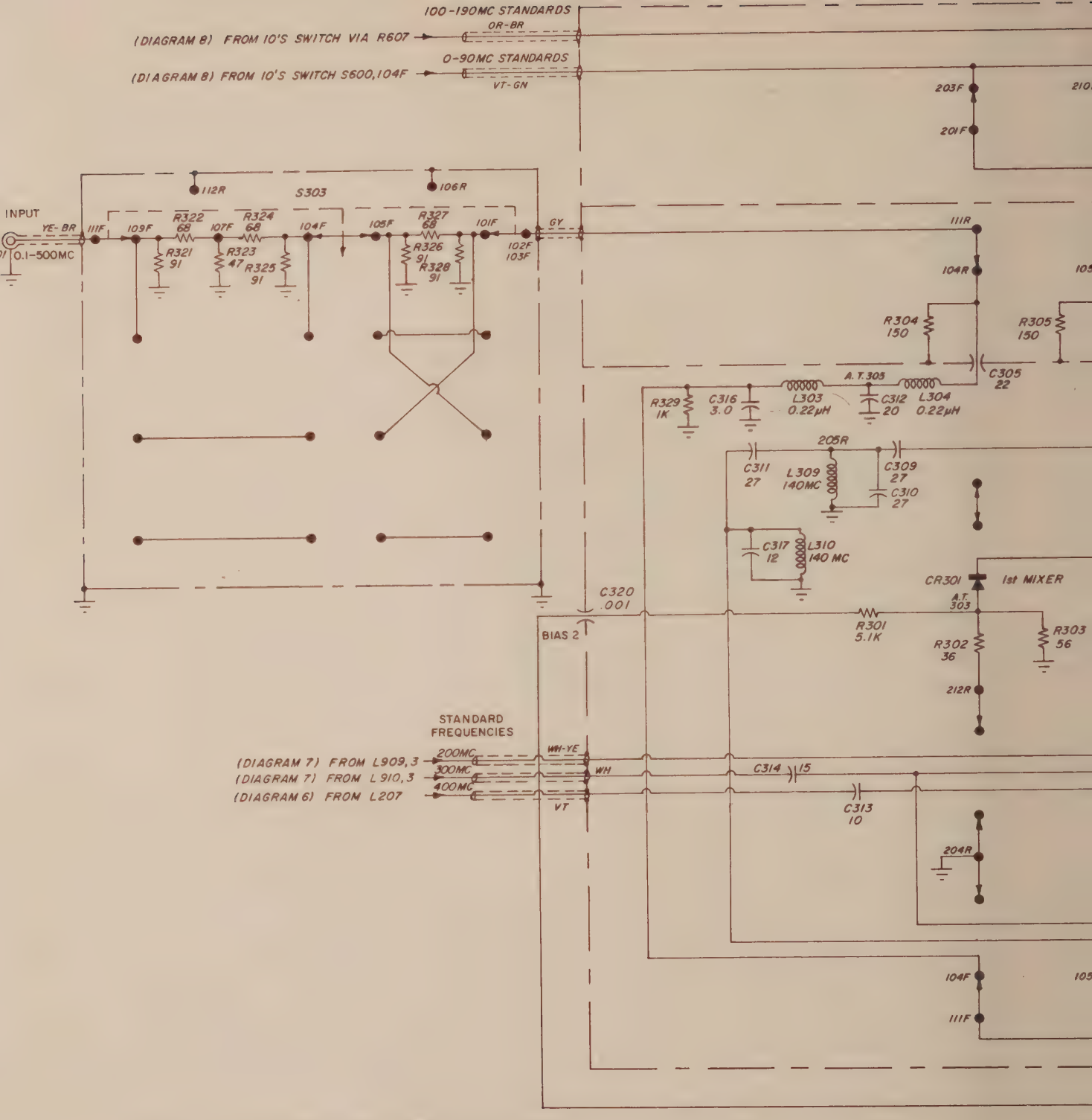


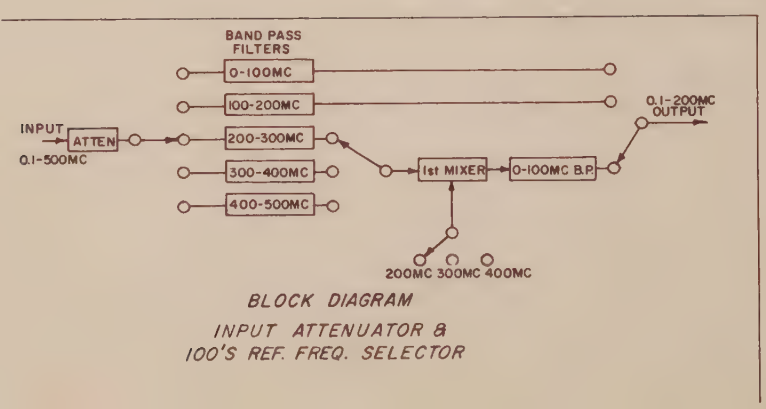
Figure 5-6. 10's Reference-Frequency Generator (shield cover removed).

PARTS LIST

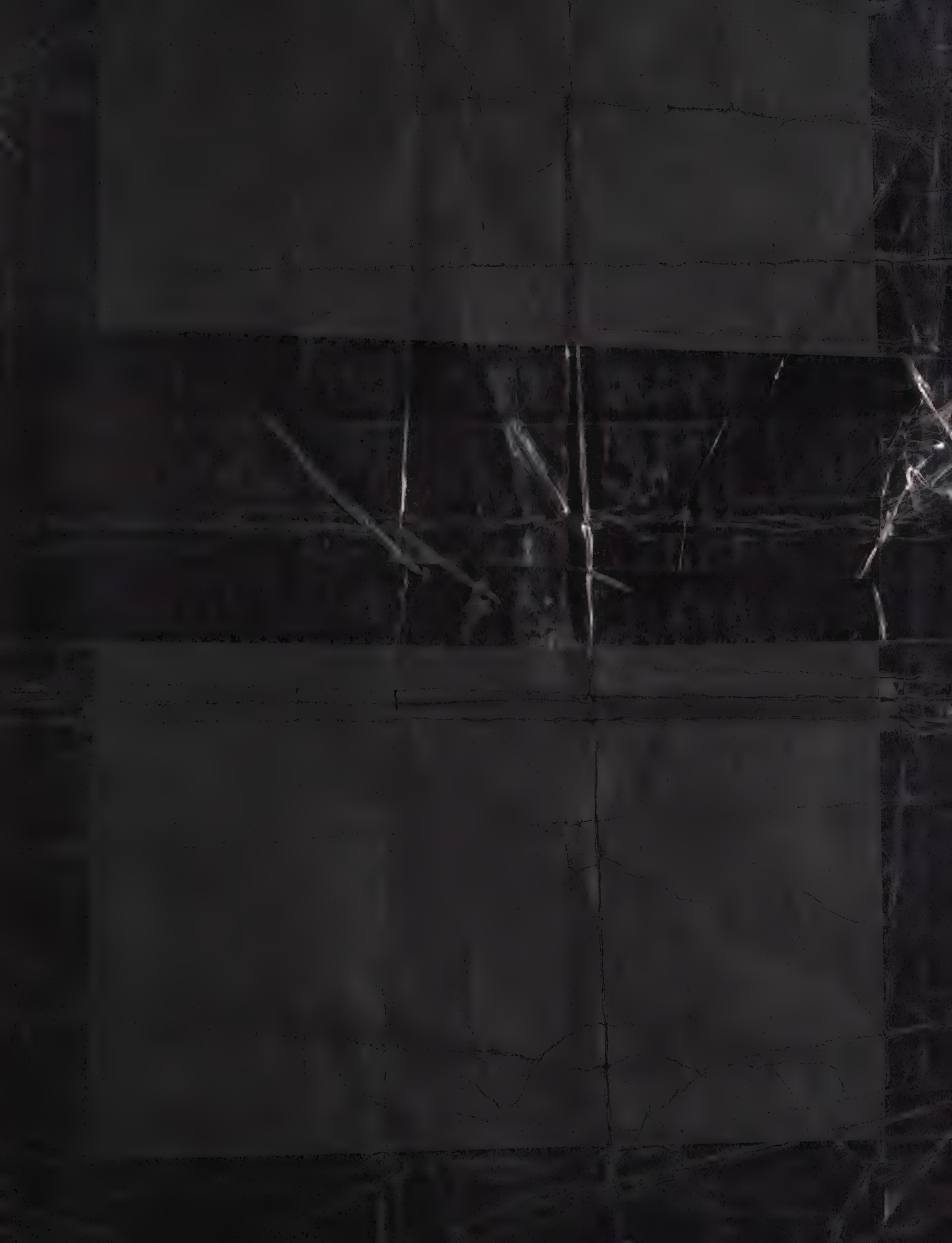
REF NO.	RESISTORS	PART NO.
R301	Composition, 5.1kΩ ±5% 1/2w	6100-2515
R302	Composition, 36Ω ±5% 1/2w	6100-0365
R303	Composition, 56Ω ±5% 1/2w	6100-0565
R304	Composition, 150Ω ±5% 1/2w	6100-1155
R305	Composition, 150Ω ±5% 1/2w	6100-1155
R306	Composition, 10kΩ ±10% 2w	6120-3109
R307	Composition, 22kΩ ±10% 1w	6110-3229
R321	Composition, 91Ω ±5% 1/2w	6100-0915
R322	Composition, 68Ω ±5% 1/2w	6100-0685
R323	Composition, 47Ω ±5% 1/2w	6100-0475
R324	Composition, 68Ω ±5% 1/2w	6100-0685
R325	Composition, 91Ω ±5% 1/2w	6100-0915
R326	Composition, 91Ω ±5% 1/2w	6100-0915
R327	Composition, 68Ω ±5% 1/2w	6100-0685
R328	Composition, 91Ω ±5% 1/2w	6100-0915
R329	Composition, 1kΩ ±5% 1/2w	6100-2105
R330	Composition, 1kΩ ±5% 1/2w	6100-2105
	CAPACITORS	
C301	Ceramic, 8.2pf ±10% 500dcwv	4400-1880
C302	Ceramic, 12pf ±10% 500dcwv	4400-1885
C303	Ceramic, 22pf ±10% 500dcwv	4400-1895
C304	Ceramic, 12pf ±10% 500dcwv	4400-1885
C305	Ceramic, 22pf ±10% 500dcwv	4400-1895
C306 thru C308	Trimmer, 0.8-8.5pf	4910-1100
C309	Ceramic, 27pf ±5% N33 500dcwv	4411-0275
C310	Ceramic, 27pf ±5% N33 500dcwv	4411-0275
C311	Ceramic, 27pf ±5% N33 500dcwv	4411-0275
C312	Ceramic, 20pf ±5% N33 500dcwv	4411-0205
C313	Ceramic, 10pf ±5% N33 500dcwv	4411-0105
C314	Ceramic, 15pf ±5% N33 500dcwv	4411-0155

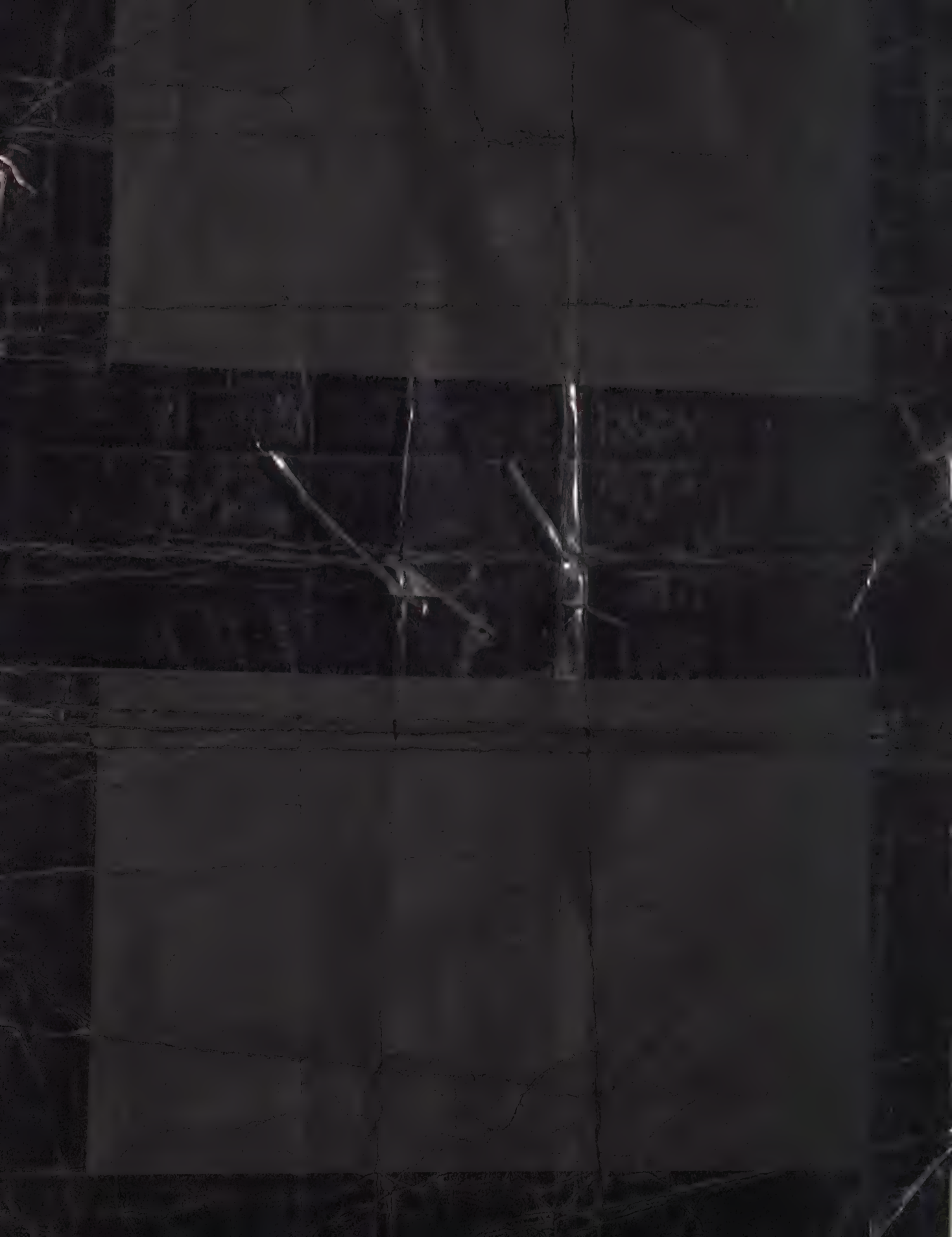
REF NO.	CAPACITORS	PART NO.
C315	Ceramic, 3.0pf ±5% 500dcwv	4400-0350
C316	Ceramic, 3.0pf ±5% 500dcwv	4400-0350
C317	Ceramic, 12pf ±5% N33 500dcwv	4411-0125
C318	Ceramic, 20pf ±5% N33 500dcwv	4411-0105
C319	Ceramic, 20pf ±5% N33 500dcwv	4411-0205
C320	Ceramic, .001μf +100-0% 500dcwv	4400-2049
	INDUCTORS	
L301 thru L304	0.22μh ±20%	4300-0200
L305	1 1/4 Long	1133-6321
L306		1133-6322
L307		1133-6323
L308		1133-6324
L309		1133-6325
L310		1133-6326
L311		
	DIODES	
CR301	1005/1N21C	6084-1005
	SWITCHES	
S300		7890-3050
S301		7890-3060
S302		7890-3070
S303		7890-3080





BLOCK DIAGRAM
INPUT ATTENUATOR & 100'S REF. FREQ. SELECTOR





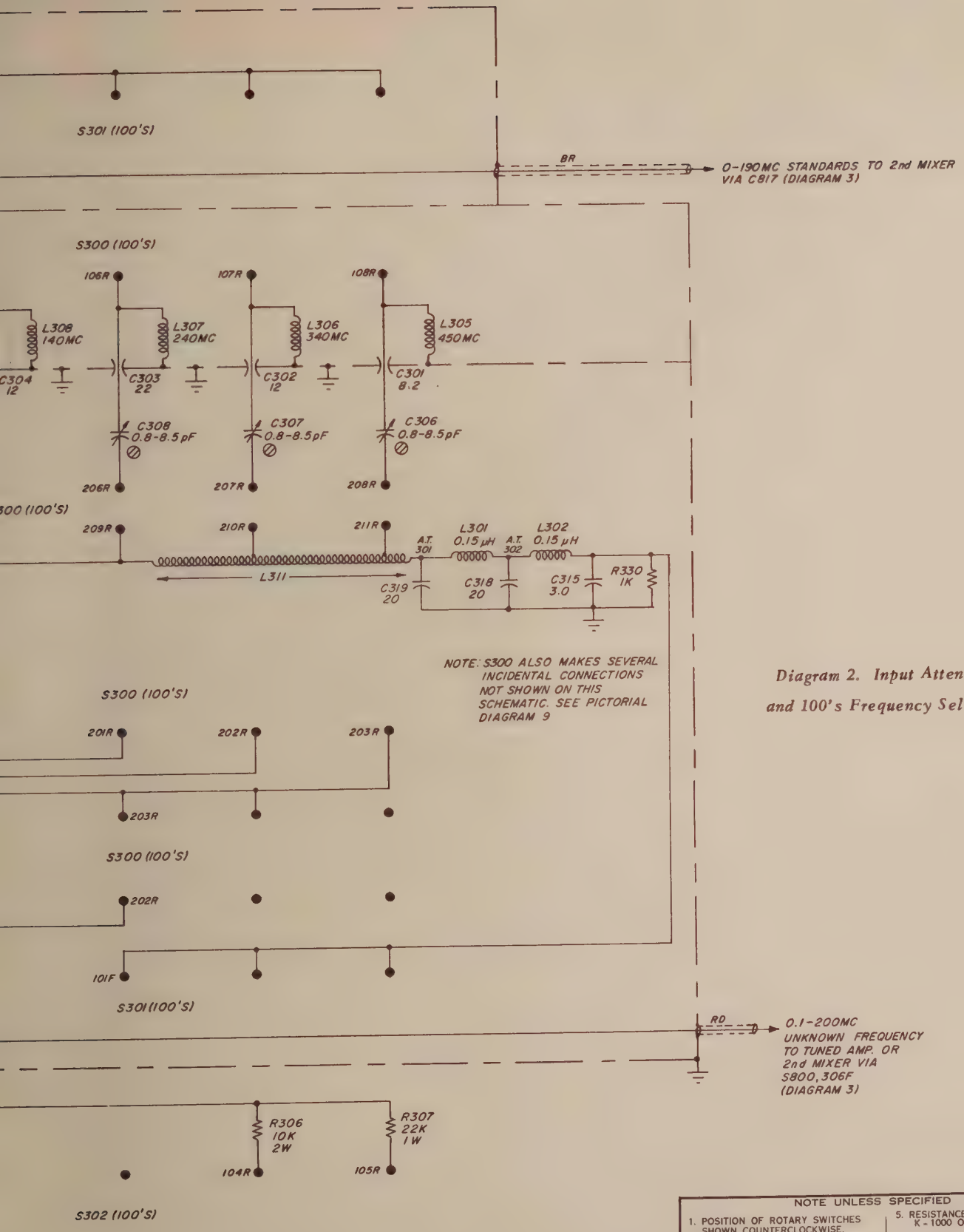


Diagram 2. Input Attenuator and 100's Frequency Selector.

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/2 WATT.
5. RESISTANCE IN OHMS K - 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT - ANCHOR TERMINAL
10. TP - TEST POINT

PARTS LIST

REF NO.	RESISTORS	PART NO.
R800	Composition, 910kΩ ±5% 1/2w	6100-4915
R801	Composition, 91Ω ±5% 1/2w	6100-0915
R802	Composition, 100kΩ ±5% 1/2w	6100-4105
R803	Composition, 510Ω ±5% 1w	6110-1515
R804	Composition, 10Ω ±5% 1/2w	6100-0105
R805	Composition, 18kΩ ±5% 1/2w	6100-3185
R806	Composition, 100Ω ±5% 1/2w	6100-1105
R807	Composition, 82kΩ ±5% 1/2w	6100-3825
R808	Composition, 15Ω ±5% 1/2w	6100-0155
R809 thru R813	Composition, 100Ω ±5% 1/2w	6100-1105
R814	Composition, 110Ω ±5% 1/2w	6100-1115
R815	Composition, 510Ω ±5% 1/2w	6100-1515
R816	Composition, 1.1kΩ ±5% 1/2w	6100-2115
R817	Composition, 510Ω ±5% 1/2w	6100-1515
R818	Composition, 100Ω ±5% 1/2w	6100-1105
R819	Composition, 510Ω ±5% 1/2w	6100-1515
R820	Pot., Composition, 1kΩ ±10%	6010-0400
R821	Composition, 510Ω ±5% 1/2w	6100-1515
R822	Composition, 110Ω ±5% 1/2w	6100-1115
R823	Composition, 75kΩ ±5% 1/2w	6100-3755
R858	Composition, 10Ω ±5% 1/2w	6100-0105
R859	Composition, 100Ω ±5% 1/2w	6100-1105
R865	Composition, 500kΩ ±5%	6010-2200
R866	Composition, 20Ω ±5% 1/2w	6100-0205
R867	Power, 10kΩ ±5% 5w	6660-3105
R868	Power, 15kΩ ±5% 5w	6660-3155

CAPACITORS

C800	Ceramic, 0.001μf +100-10% 500dcwv	4400-2049
C801	Ceramic, 0.001μf ±20% 500dcwv	4404-2109
C802	Ceramic, 0.001μf +100-10% 500dcwv	4400-1600
C803	Ceramic, 0.01μf ±20% 500dcwv	4406-3109
C804A	8-50pf 1000dcwv	1133-0480
C804B	8-50pf 1000dcwv	1133-0480
C805	Ceramic, 6.8pf ±5% 500dcwv	4400-0680
C806	Ceramic, 0.01μf ±20% 500dcwv	4406-3109
C807	Ceramic, 0.01μf ±20% 500dcwv	4406-3109
C808	Ceramic, 0.001μf +100-10% 500dcwv	4400-2049
C809	Ceramic, 0.001μf +100-10% 500dcwv	4400-1600
C810	Ceramic, 0.01μf ±20% 500dcwv	4406-3109
C811	Ceramic, 0.01μf ±20% 500dcwv	4406-3109
C812 thru C814	Ceramic, 0.001μf +100-0% 500dcwv	4400-2049
C815	Ceramic, 0.001μf +100-0% 500dcwv	4400-1600
C816	Ceramic, 0.01μf ±20% 500dcwv	4406-3109

REF NO.	CAPACITORS	PART NO.
C817	Ceramic, 0.01μf ±20% 500dcwv	4406-3109
C818	Ceramic, 0.001μf +100-0% 500dcwv	4400-2049
C838	Ceramic, 0.001μf ±20% 500dcwv	4404-2109
C840	Ceramic, 0.001μf +100-0% 500dcwv	4400-2049
C846	Electrolytic, 4000μf 10dcwv	4450-4200

INDUCTORS

L800	0.05μh	1133-6820
L801	0.20μh	1133-6830
L802	1.26μh	1133-0400
L803	5.05μh	1133-0410
L804	0.47μh ±20%	4300-0400

TRANSISTORS

Q801	TR14/2N1544	8210-1014
Q802	TR33/2N696	8210-1033

DIODES

CR804	1017/1N994	6082-1017
CR808	1002/1N748A	6083-1002
CR809 thru CR812	1001/1N3253	6081-1002

PLUGS

P801 thru P805	Type 765	

SWITCHES

S302		7890-3070
S602		7890-3150
S800		7890-3040
S801		7890-3170

TUBES

V800	7788	8380-7788
V801	6AU6	8360-2100
V802	6AU6	8360-2100
V803	5651	8380-5651

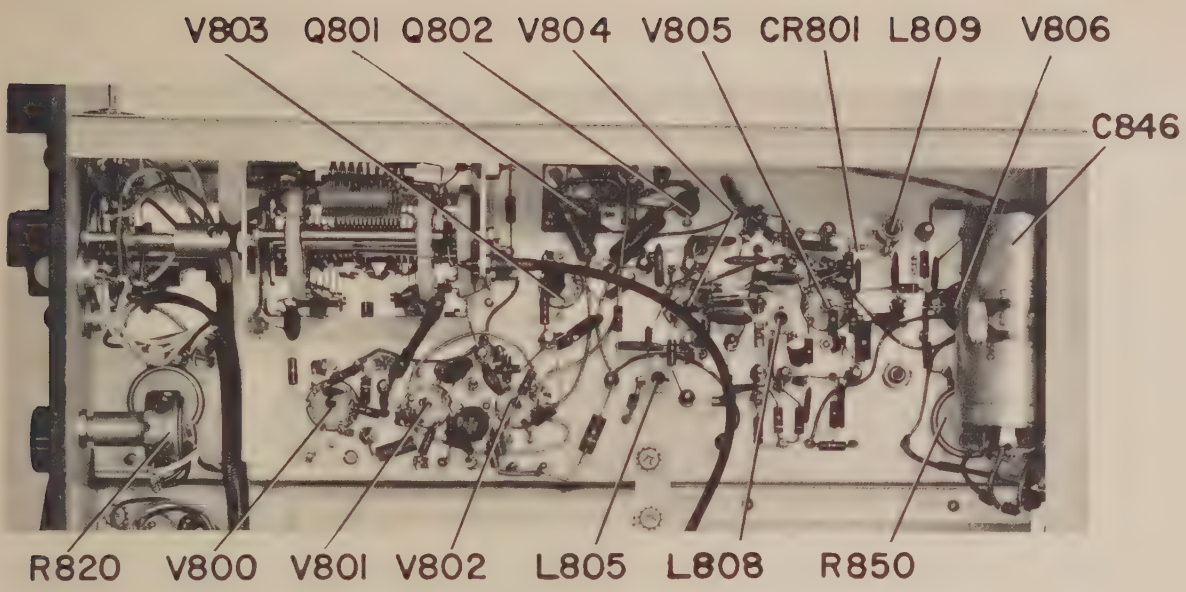
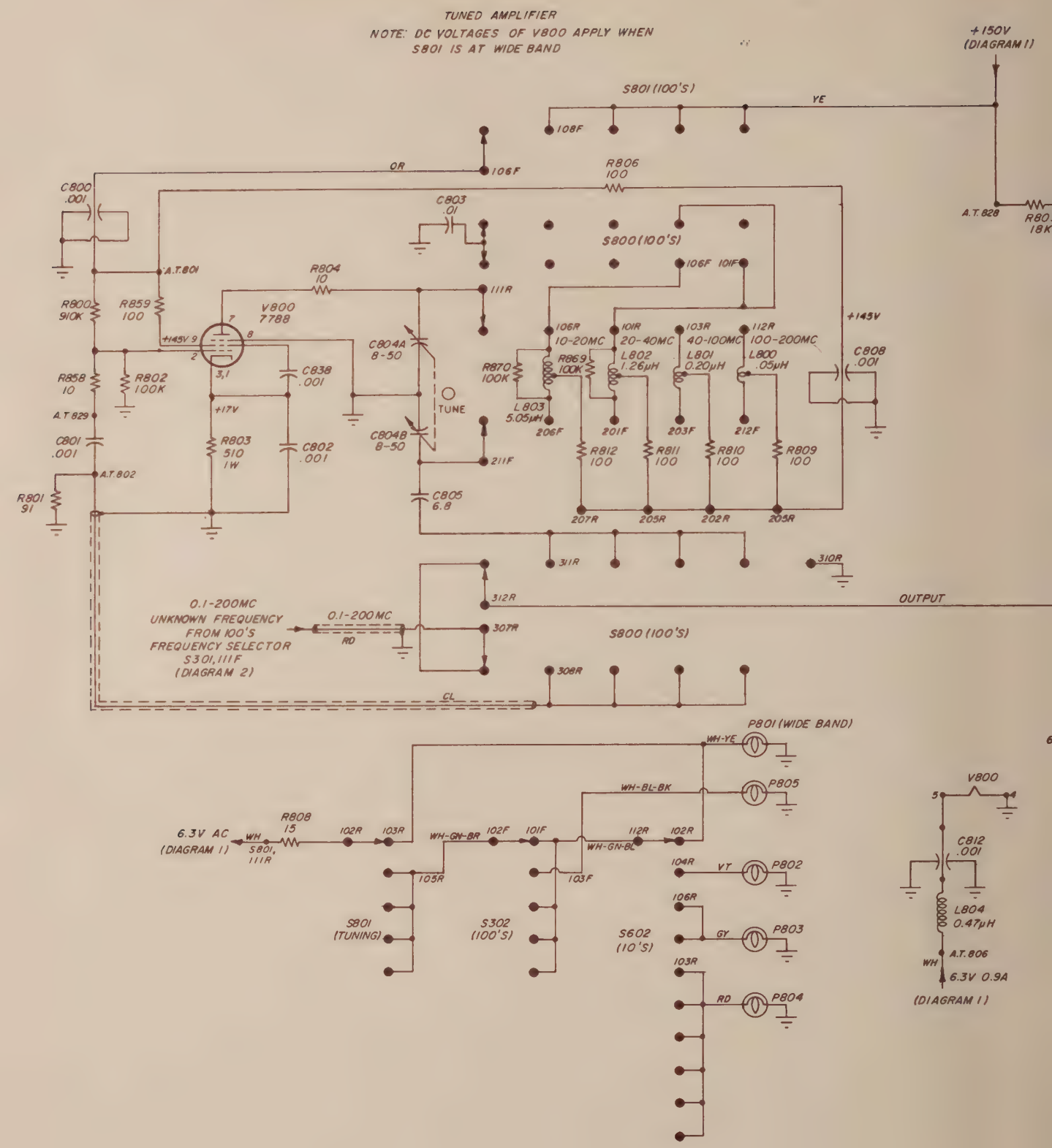


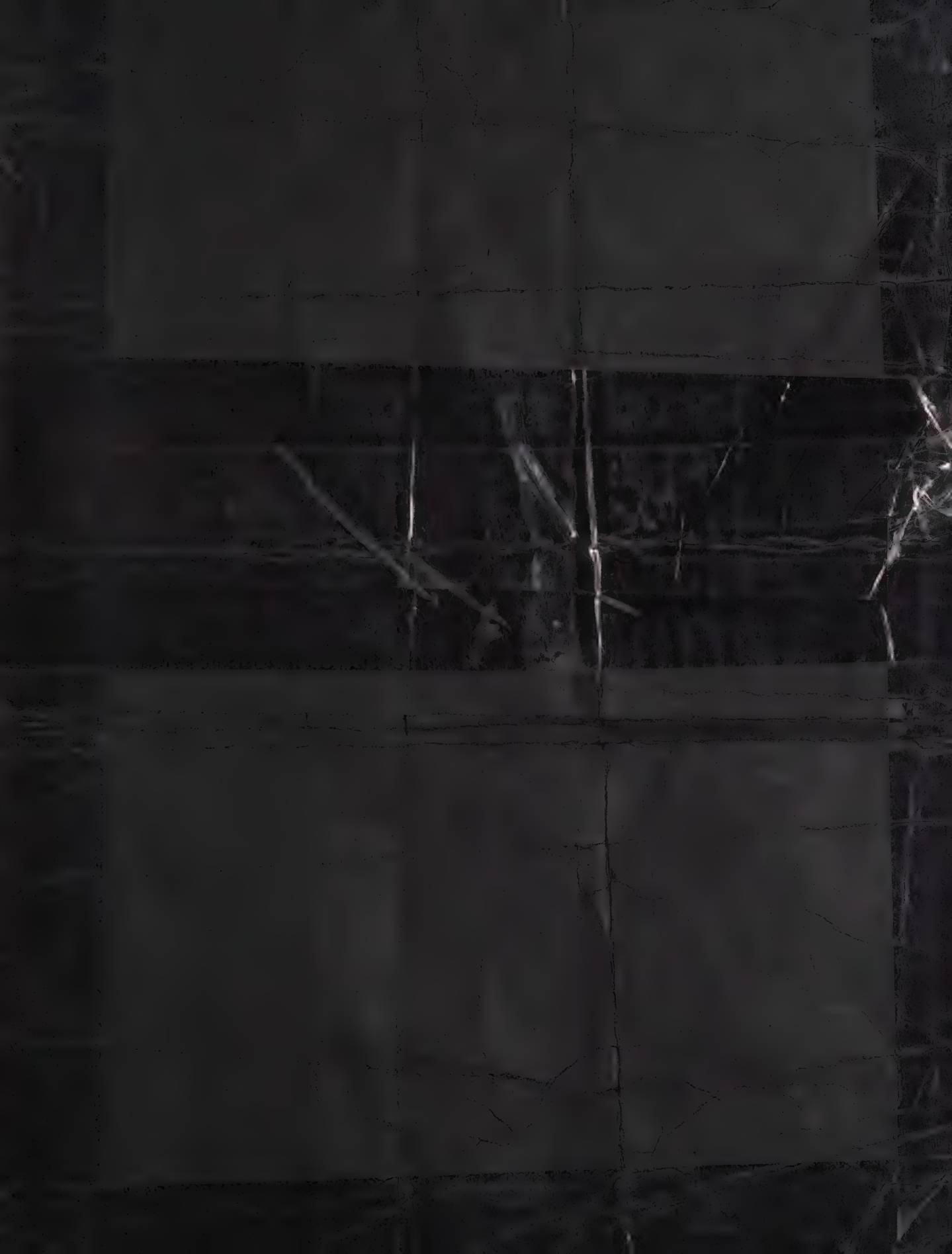
Figure 5-7. Tuned Amplifier, 2nd Mixer, and Video Amplifier.

RESISTANCE TABLE*

Tube	(Type)	Pin	Resistance to Ground
V800	(7788)	1,3	510
		2	90 k
		7	210
		8	0
		9	100
V801, V802	(6AU6)	1	510
		2	0
		5	101 k
		6	100 k
		7	1 k

*Refer to notes on page 19.


TUNED AMPLIFIER
NOTE: DC VOLTAGES OF V800 APPLY WHEN S801 IS AT WIDE BAND
+150V (DIAGRAM 1)
S801 (100'S)
YE
108F
OR
106F
R806 100
C800 .001
C803 .01
A.T.801
R804 10
S800 (100'S)
106F 101F
111R
R800 910K
R859 100
V800 7788
+145V
C804A 8-50
C838 .001
R858 10
R802 100K
A.T.829
+17V
TUNE
C804B 8-50
R803 510 1W
C802 .001
C801 .001
A.T.802
211F
C805 6.8
R801 91
R870 100K
R869 100K
L803 5.05μH
106R 10-20MC
101R 20-40MC
103R 40-100MC
112R 100-200MC
L802 1.26μH
L801 0.20μH
L800 .05μH
C808 .001
206F
201F
203F
212F
R812 100
R811 100
R810 100
R809 100
207R
205R
202R
205R
311R
310R
312R
OUTPUT
0.1-200MC UNKNOWN FREQUENCY FROM 100'S FREQUENCY SELECTOR S301, 111F (DIAGRAM 2)
0.1-200MC
RD
307R
S800 (100'S)
308R
CL
P801 (WIDE BAND)
WH-YE
P805
WH-BL-BK
R808 15
6.3V AC (DIAGRAM 1)
WH
S801, 111R
102R
103R
WH-GN-BR
102F
101F
WH-GN-BL
112R
102R
105R
103F
104R
VT
P802
106R
GY
P803
S801 (TUNING)
S302 (100'S)
S602 (10'S)
103R
RD
P804
V800
5
4
C812 .001
L804 0.47μH
A.T.806
WH
6.3V 0.9A
(DIAGRAM 1)



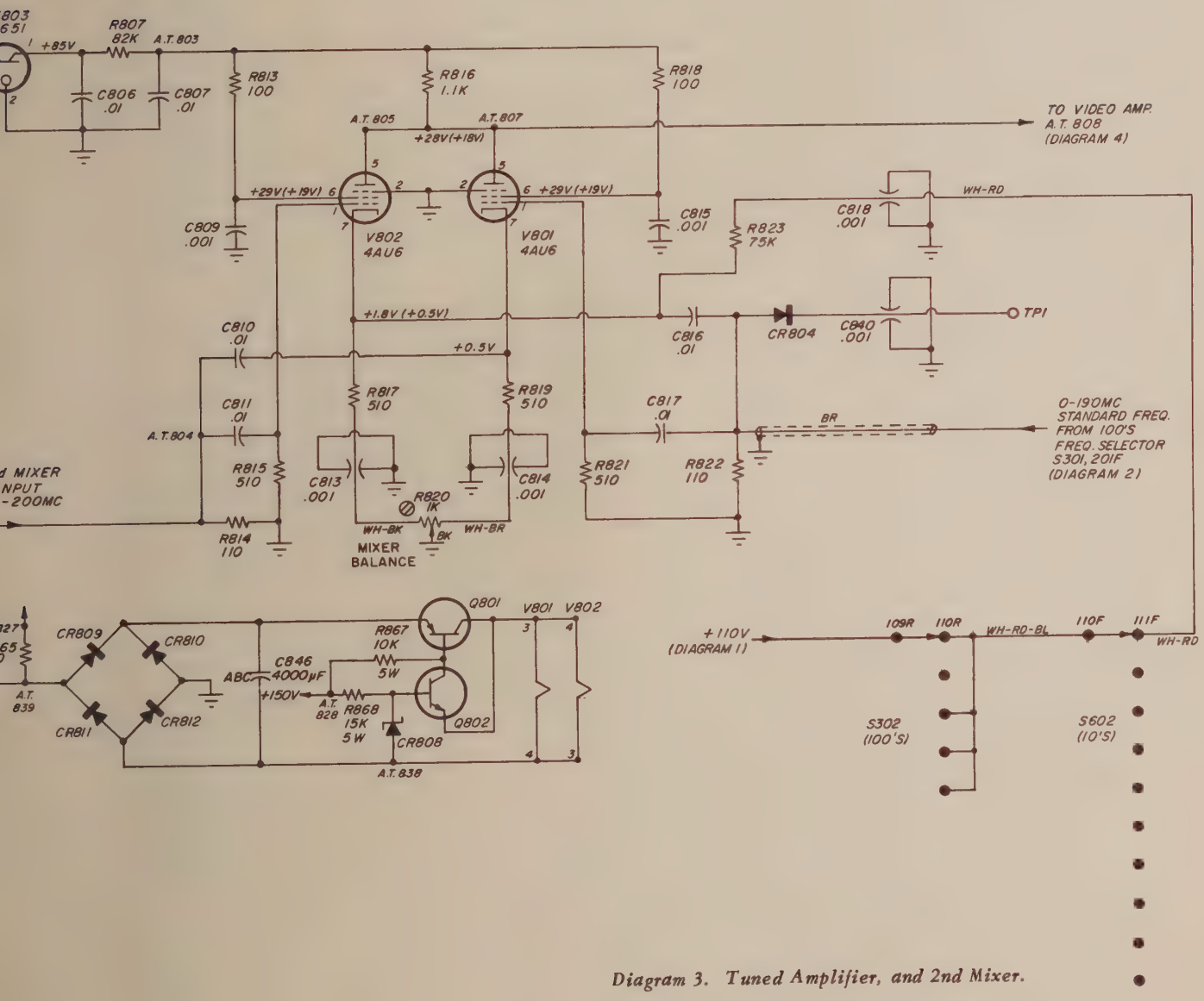


Diagram 3. Tuned Amplifier, and 2nd Mixer.

NOTE UNLESS SPECIFIED	
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.	5. RESISTANCE IN OHMS K - 1000 OHMS M - 1 MEGOHM
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.	6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.	7. ◯ KNOB CONTROL
4. RESISTORS 1/2 WATT.	8. ⊘ SCREWDRIVER CONTROL
	9. AT - ANCHOR TERMINAL
	10. TP - TEST POINT

PARTS LIST

REF NO.	RESISTORS	PART NO.
R824	Composition, 150kΩ ±5% 1/2w	6100-4155
R825	Composition, 10kΩ ±5% 1/2w	6100-2305
R826	Composition, 2.4kΩ ±5% 1/2w	6100-2245
R827	Composition, 1kΩ ±5% 1/2w	6100-2105
R828	Composition, 68Ω ±5% 1/2w	6100-0685
R829	Composition, 2.4kΩ ±5% 1/2w	6100-2245
R830	Pot., Composition, 25kΩ ±10%	6000-0700
R831	Composition, 5.1kΩ ±5% 1/2w	6100-2515
R832	Composition, 10kΩ ±5% 1/2w	6100-2305
R833	Composition, 2.4kΩ ±5% 1/2w	6100-2245
R834	Composition, 1kΩ ±5% 1/2w	6100-2105
R835	Composition, 68Ω ±5% 1/2w	6100-0685
R836	Composition, 2.4kΩ ±5% 1/2w	6100-2245
R837	Composition, 10kΩ ±5% 1/2w	6100-2305
R838	Composition, 2.4kΩ ±5% 1/2w	6100-2245
R839	Composition, 1kΩ ±5% 1/2w	6100-2105
R840	Composition, 68Ω ±5% 1/2w	6100-0685
R841	Composition, 2.4kΩ ±5% 1/2w	6100-2245
R842	Composition, 2M ±5% 1/2w	6100-5205
R843	Composition, 1kΩ ±5% 1/2w	6100-2105
R844	Composition, 1M ±5% 1/2w	6100-5105
R845	Composition, 100Ω ±5% 1/2w	6100-1105
R846	Composition, 5.1kΩ ±5% 1w	6110-2515
R847	Composition, 10kΩ ±5% 1/2w	6100-3105
R848	Composition, 1M ±5% 1/2w	6100-5105
R849	Composition, 100kΩ ±5% 1/2w	6100-4105
R850	Pot., Composition, 50kΩ ±10%	6010-1400
R851	Composition, 100kΩ ±5% 1/2w	6100-4105
R852	Composition, 1M ±5% 1/2w	6100-5105
R853	Composition, 2M ±5% 1/2w	6100-5205
R854	Composition, 10kΩ ±5% 1/2w	6100-3105
R855	Composition, 1M ±5% 1/2w	6100-4515
R856	Composition, 150kΩ ±5% 1/2w	6100-4155
R857	Composition, 130Ω ±5% 1/2w	6100-1135
R860 thru R864	Composition, 10kΩ ±5% 1/2w	6100-3105

CAPACITORS

C819	Ceramic, 3pf ±5% 500dcwv	4400-0350
C820	Ceramic, 0.01µf ±20% 500dcwv	4406-3109
C821	Ceramic, 0.001µf ±20% 500dcwv	4404-2109
C822	Ceramic, 0.001µf ±20% 500dcwv	4404-2109
C823	Ceramic, 0.1µf +80-20% 50dcwv	4403-3100
C824	Ceramic, 0.01µf ±20% 500dcwv	4406-3109
C825	Ceramic, 0.1µf +80-20% 50dcwv	4403-3100
C826	Ceramic, 0.001µf ±20% 500dcwv	4404-2109

REF NO.	CAPACITORS	PART NO.
C827	Ceramic, 0.1µf +80-20% 50dcwv	4403-3100
C828	Ceramic, 0.01µf ±20% 500dcwv	4406-3109
C829	Ceramic, 0.001µf ±20% 500dcwv	4404-2109
C830	Ceramic, 0.1µf +80-20% 50dcwv	4403-3100
C831 thru C833	Ceramic, 0.01µf ±20% 500dcwv	4406-3109
C834	Ceramic, 51pf ±5% NPO 500dcwv	4410-0515
C835 thru C837	Ceramic, 0.01µf ±20% 500dcwv	4406-3109
C841	Ceramic, 0.022µf ±20% 500dcwv	4407-3229
C842 thru C845	Ceramic, 0.1µf +80-20% 500dcwv	4403-3100

INDUCTORS

L805	14.5-22.5µh	4290-4100
L806	12µh ±10%	4300-2300
L807	12µh ±10%	4300-2300
L808	22-29.5µh	4290-4200
L809	4.5-8.6µh	4290-4050

DIODES

CR801	1001/1N995	6082-1001
CR802	1008/1N191	6082-1008
CR803	1008/1N191	6082-1008
CR805 thru CR807	1016/1N676	6082-1016

METER

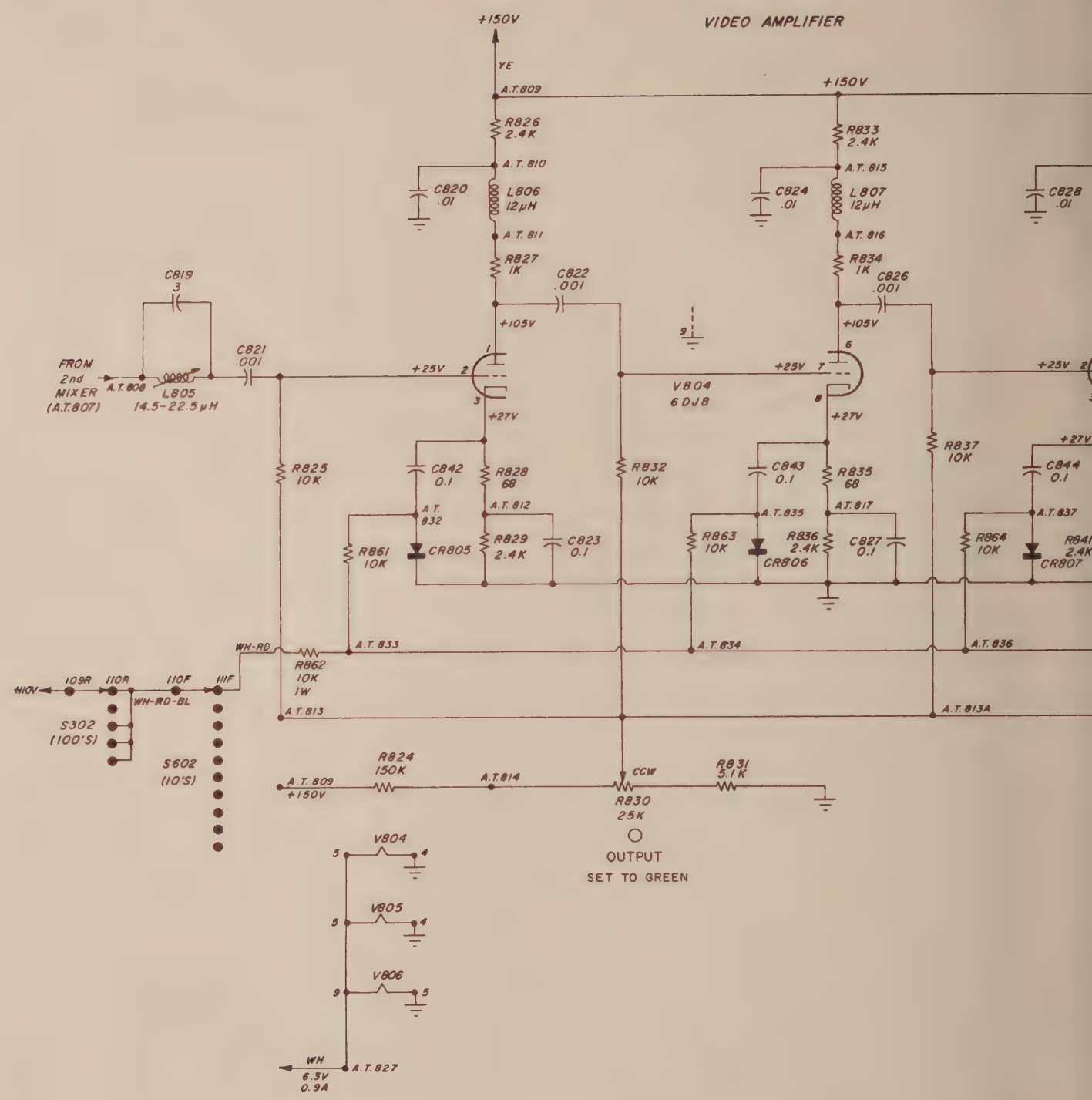
M801	200µa	5730-1369

SWITCHES

S302		7890-3070
S602		7890-3150

TUBES

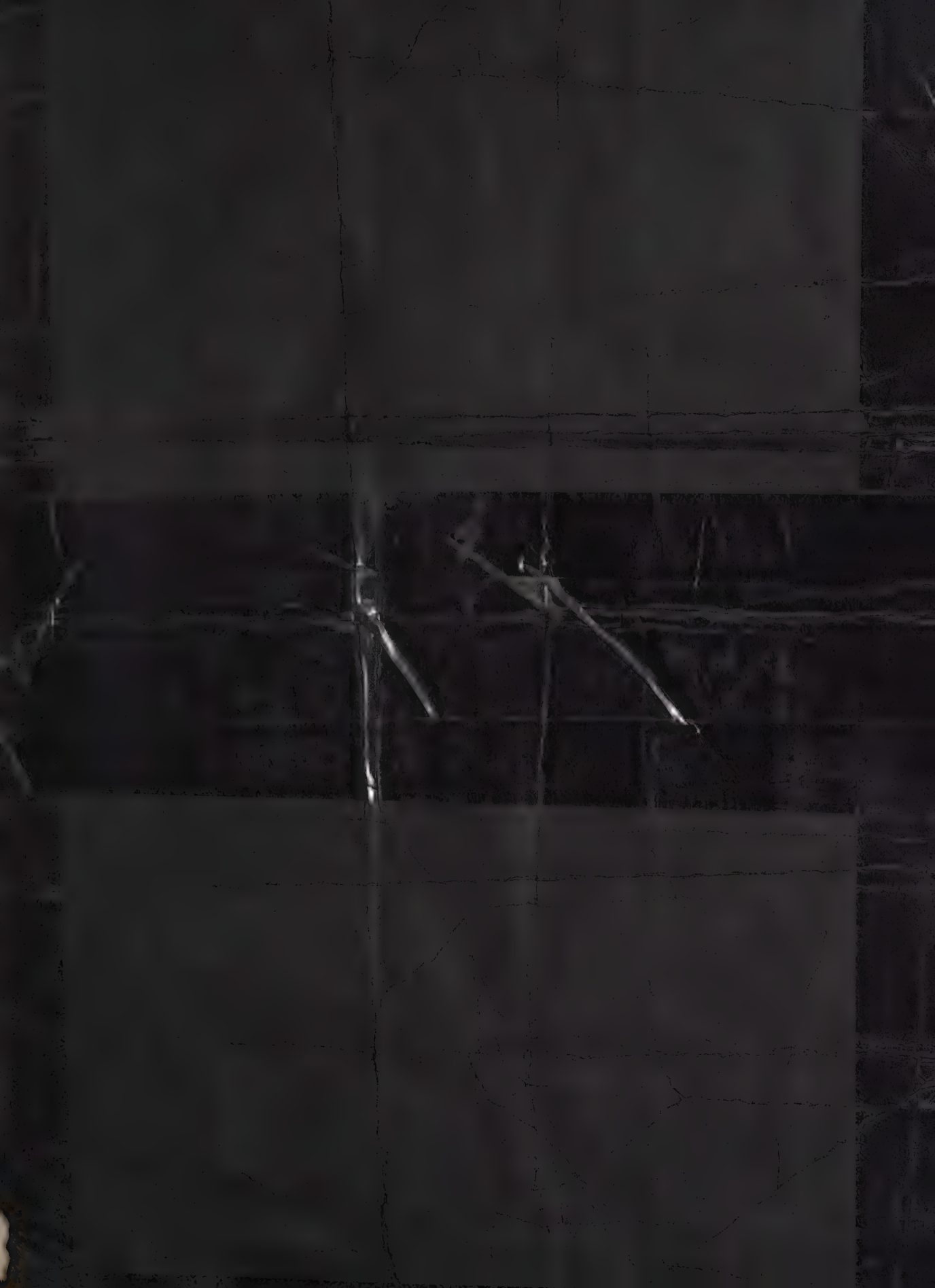
V804	6DJ8	8360-4510
V805	6DJ8	8360-4510
V806	12AX7	8370-0900

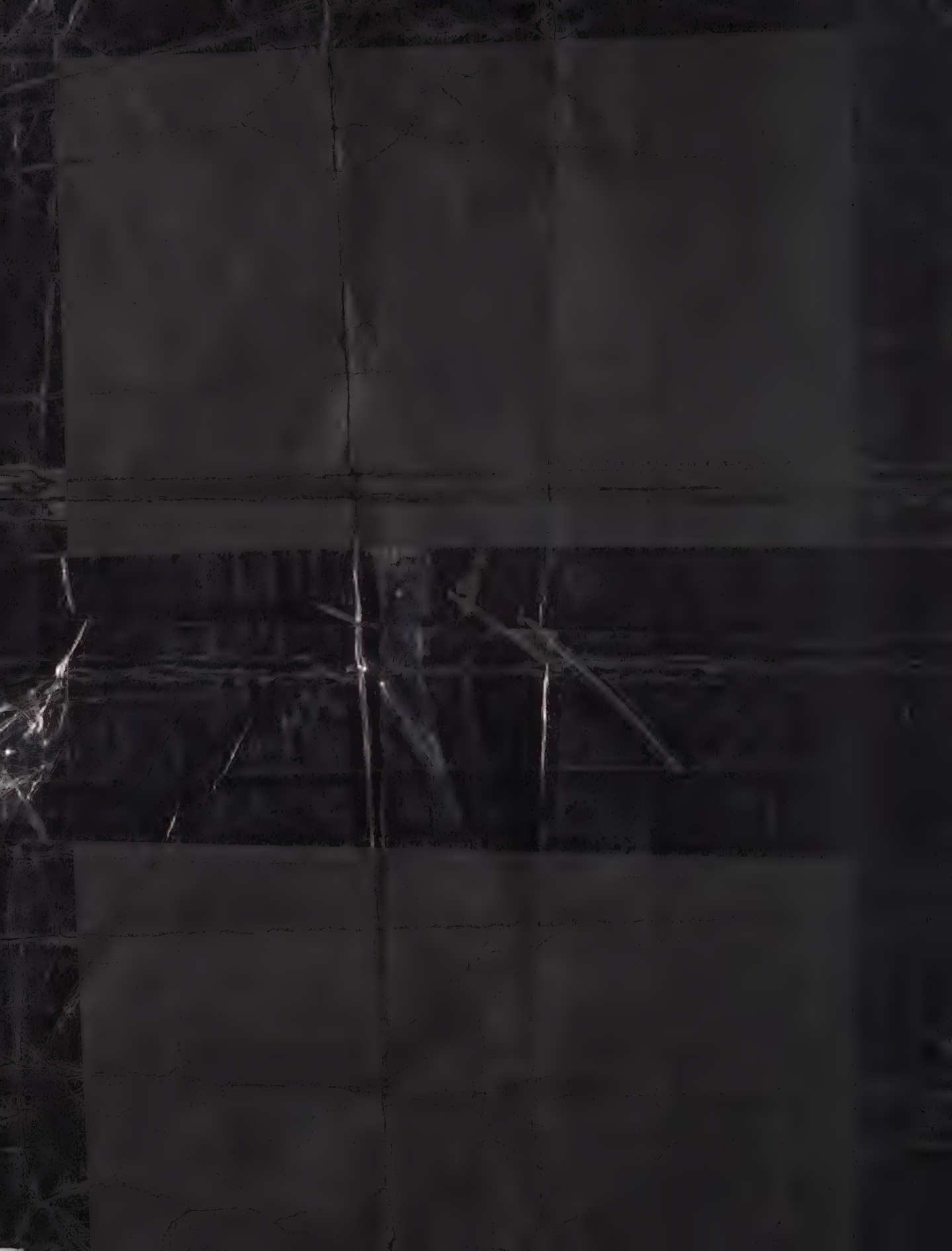


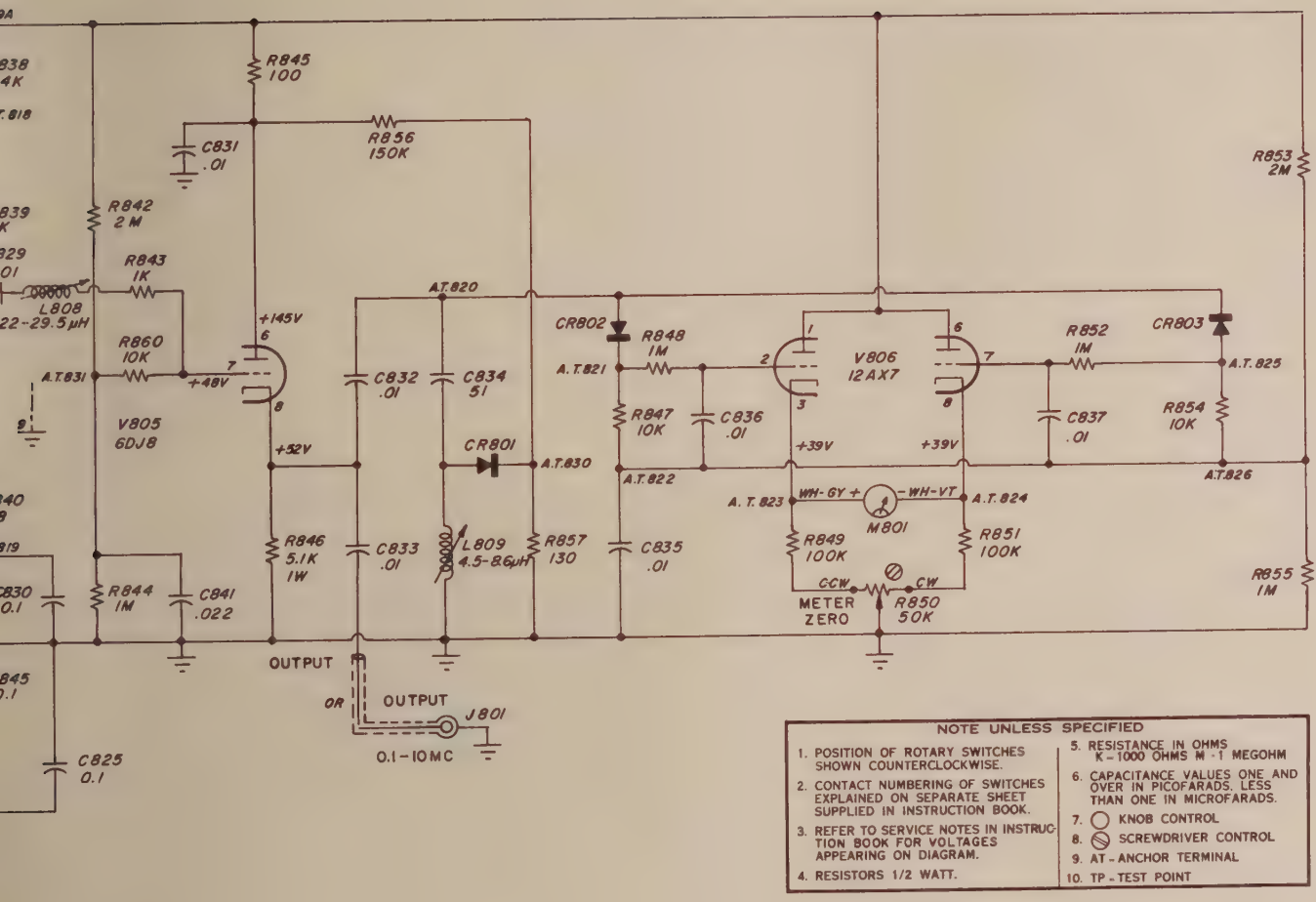
Tube	(Type)	Pin	Resistance to Ground
V804	(6DJ8)	1	3.4 k
		2	35 k
		3	2.5 k
		6	3.4 k
		7	35 k
		8	2.5 k
		9	0

Tube
V805

*Refer to notes on page 19.







NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/2 WATT.
5. RESISTANCE IN OHMS K - 1000 OHMS M - 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT - ANCHOR TERMINAL
10. TP - TEST POINT

Diagram 4. Video Amplifier and Meter Amplifier.
(NOTE: See Figure 5-7 for photograph of this section.)

ESISTANCE TABLE*

ype)	Pin	Resistance to Ground
DJ8)	1	3.4 k
	2	35 k
	3	2.5 k
	6	100
	7	677 k
	8	5.1 k
	9	0

Tube	(Type)	Pin	Resistance to Ground
V806	(12AX7)	1,6	0
		2	1 M
		3	62 k
		7	1 M
		8	62 k

REF NO.	RESISTORS	PART NO.
R401	Composition, 150Ω ±5% 1/2w	6100-1155
R402	Composition, 1kΩ ±5% 1/2w	6100-2105
R403	Composition, 100kΩ ±5% 1/2w	6100-4105
R404	Composition, 150Ω ±5% 1/2w	6100-1155
R405	Composition, 1kΩ ±5% 1/2w	6100-2105
R406	Composition, 100kΩ ±5% 1/2w	6100-4105
R407	Composition, 510Ω ±5% 1/2w	6100-1515
R408	Composition, 1kΩ ±5% 1/2w	6100-2105
R409	Composition, 10Ω ±5% 1/2w	1133-2440
R410	Composition, 510Ω ±5% 1/2w	6100-1515
R411	Composition, 1kΩ ±5% 1/2w	6100-2105
R412	Composition, 10Ω ±5% 1/2w	6100-0105
R413	Composition, 100kΩ ±5% 1/2w	6100-4105
R414	Composition, 150Ω ±5% 1/2w	6100-1155
R415	Composition, 150Ω ±5% 1/2w	6100-1155
R416	Composition, 510Ω ±5% 1/2w	6100-1515
R417	Composition, 10Ω ±5% 1/2w	6100-0105
R418	Composition, 510Ω ±5% 1/2w	6100-1515
R419	Composition, 10Ω ±5% 1/2w	1133-2440
R420	Composition, 1kΩ ±5% 1/2w	6100-2105
R421	Composition, 75Ω ±5% 1/2w	6100-0755
R422	Composition, 1kΩ ±5% 1/2w	6100-2105
R423	Composition, 75Ω ±5% 1/2w	6100-0755
R424	Composition, 200Ω ±5% 1/2w	6100-1205
R425	Composition, 100kΩ ±5% 1/2w	6100-4105
R426	Composition, 510Ω ±5% 1/2w	6100-1515
R427	Composition, 1kΩ ±5% 1/2w	6100-2105
R428	Composition, 10Ω ±5% 1/2w	1133-2440
R429	Composition, 75Ω ±5% 1/2w	6100-0755
R430	Composition, 100kΩ ±5% 1/2w	6100-4105
R431	Composition, 510Ω ±5% 1/2w	6100-1515
R432	Composition, 1kΩ ±5% 1/2w	6100-2105
R433	Composition, 75Ω ±5% 1/2w	6100-0755
R434	Composition, 75Ω ±5% 1/2w	6100-0755
R435	Composition, 100kΩ ±5% 1/2w	6100-4105
R436	Composition, 510Ω ±5% 1/2w	6100-1515
R437	Composition, 10Ω ±5% 1/2w	1133-2440
R438	Composition, 1kΩ ±5% 1/2w	6100-2105
R439	Composition, 75Ω ±5% 1/2w	6100-0755
R440	Composition, 100kΩ ±5% 1/2w	6100-4105
R441	Composition, 510Ω ±5% 1/2w	6100-1515
R442	Composition, 10Ω ±5% 1/2w	1133-2440
R443	Composition, 1kΩ ±5% 1/2w	6100-2105
R444	Composition, 75Ω ±5% 1/2w	6100-0755
R445	Composition, 390Ω ±5% 1/2w	6100-1395
R446	Composition, 100kΩ ±5% 1/2w	6100-4105
R447	Composition, 75Ω ±5% 1/2w	6100-0755
R448	Composition, 10Ω ±5% 1/2w	1133-2440
R449	Composition, 510Ω ±5% 1/2w	6100-1515
R450	Composition, 1kΩ ±5% 1/2w	6100-2105
R451	Composition, 75Ω ±5% 1/2w	6100-0755
R452	Composition, 100kΩ ±5% 1/2w	6100-4105
R453	Composition, 510Ω ±5% 1/2w	6100-1515
R454	Composition, 10Ω ±5% 1/2w	1133-2440
R455	Composition, 1kΩ ±5% 1/2w	6100-2105
R456	Composition, 75Ω ±5% 1/2w	6100-0755

REF NO.	CAPACITORS	PART NO.
C401	Mica, 150pf ±5% 500dcwv	4640-0600
C402	Ceramic, 0.01µf ±20% 500dcwv	4406-3109
C403	Ceramic, 0.01µf ±20% 500dcwv	4406-3109
C404	Mica, 150pf ±5% 500dcwv	4640-0600
C405	Mica, 33pf ±10% 500dcwv	4620-0653
C406	Ceramic, 0.01µf ±20% 500dcwv	4406-3109
C407	Mica, 130pf ±5% 500dcwv	4640-0530
C408	Ceramic, 0.001µf ±20% 500dcwv	4404-2109
C409	Oil, 0.01µf ±20% 600dcwv	4516-3109
C410	Oil, 0.01µf ±20% 600dcwv	4516-3109
C411	Mica, 33pf ±10% 500dcwv	4620-0653
C412	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C413	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C414	Ceramic, 15pf ±5% N33 500dcwv	4411-0155
C415	Air, 1 8-13pf	4380-6013
C416	Mica, 130pf ±5% 500dcwv	4640-0530
C417	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C418	Mica, 33pf ±10% 500dcwv	4620-0653
C419	Ceramic, 33pf ±5% N33 500dcwv	4411-0335
C420	Unclassified, 200pf ±10% 500dcwv	4920-1900
C421	Ceramic, 18pf ±5% N33 500dcwv	4411-0185
C422	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C423	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C424	Ceramic, 62pf ±5% N33 500dcwv	4411-0625
C425	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C426	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C427	Mica, 33pf ±10% 500dcwv	4620-0653
C428	Ceramic, 27pf ±5% N33 500dcwv	4411-0275
C429	Ceramic, 33pf ±5% N33 500dcwv	4411-0335
C430	Unclassified, 200pf ±10% 500dcwv	4920-1900
C431	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C432	Mica, 33pf ±10% 500dcwv	4620-0653
C433	Ceramic, 0.001µf +100-0% 500dcwv	4400-2049
C434	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C435	Ceramic, 6.2pf ±5% N33 500dcwv	4411-9625
C436	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C437	Ceramic, 27pf ±5% N33 500dcwv	4411-0275
C438	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C439	Mica, 33pf ±10% 500dcwv	4620-0653
C440	Ceramic, 0.001µf +100-0% 500dcwv	4400-2049
C441	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C442	Ceramic, 39pf ±5% N33 500dcwv	4411-0395
C443	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C444	Mica, 33pf ±10% 500dcwv	4620-0653
C445	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C446	Ceramic, 33pf ±5% N33 500dcwv	4411-0335
C447	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C448	Ceramic, 0.001µf +100-0% 500dcwv	4400-2049
C449	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C450	Ceramic, 33pf ±5% N33 500dcwv	4411-0335
C451	Mica, 33pf ±10% 500dcwv	4620-0653
C452	Ceramic, 0.001µf +100-0% 500dcwv	4400-2049
C453	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C454	Ceramic, 20pf ±5% N33 500dcwv	4411-0205
C455	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C456	Mica, 33pf ±10% 500dcwv	4620-0653
C457	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C458	Ceramic, 20pf ±5% N33 500dcwv	4411-0205
C459	Ceramic, 0.001µf +100-0% 500dcwv	4400-1600
C460	Ceramic, 0.01uf ±20% 500dcwv	4406-3109

REF NO.	INDUCTORS	PART NO.
L401	4.5-8.6µh	4290-4050
L402	4.5-8.6µh	4290-4050
L403	1.6 - 2.7µh	4290-4030
L404	0.3µh	1133-2403
L405	1.6-2.8µh	4290-4030
L406	0.3µh	1133-2410
L407	0.8µh	1133-2400
L408	0.2µh	1133-2411
L409	0.2µh	1133-2404
L410	0.4µh	1133-2402
L411	0.1µh	1133-2405
L412	0.1µh	1133-2405
L413	0.6µh	1133-2401
L414	0.1µh	1133-2420
L415	0.3µh	1133-2403
L416	0.1µh	1133-2405
L417	0.8µh ±20%	1133-2430

REF NO.	DIODES	PART NO.
CR401 thru CR403	1017/1N994	6082-1017

REF NO.	SWITCHES	PART NO.
S602		7890-3150

REF NO.	TUBES	PART NO.
V401	6AU6	8360-2100
V402	6AU6	8360-2100
V403 thru V407	6922	8380-6922

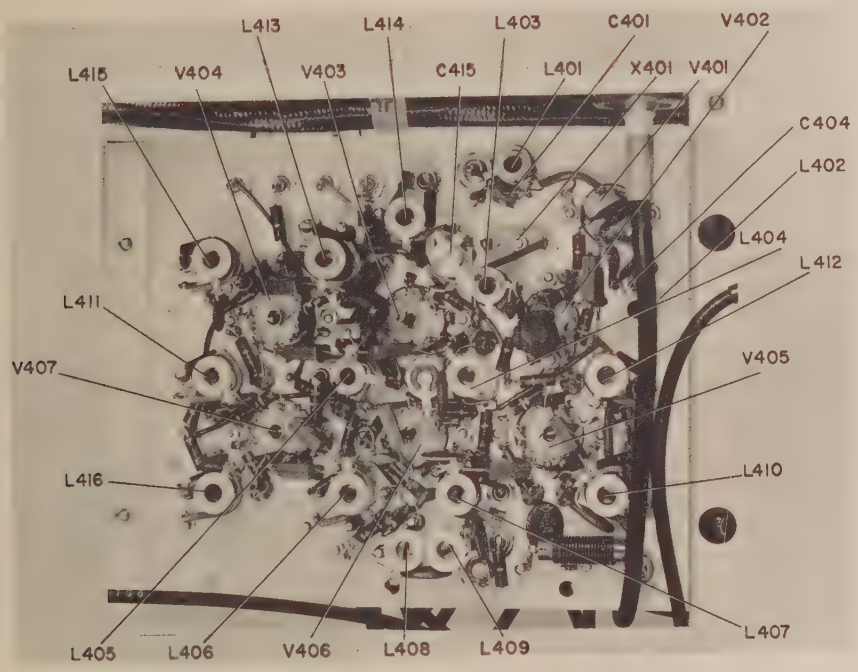
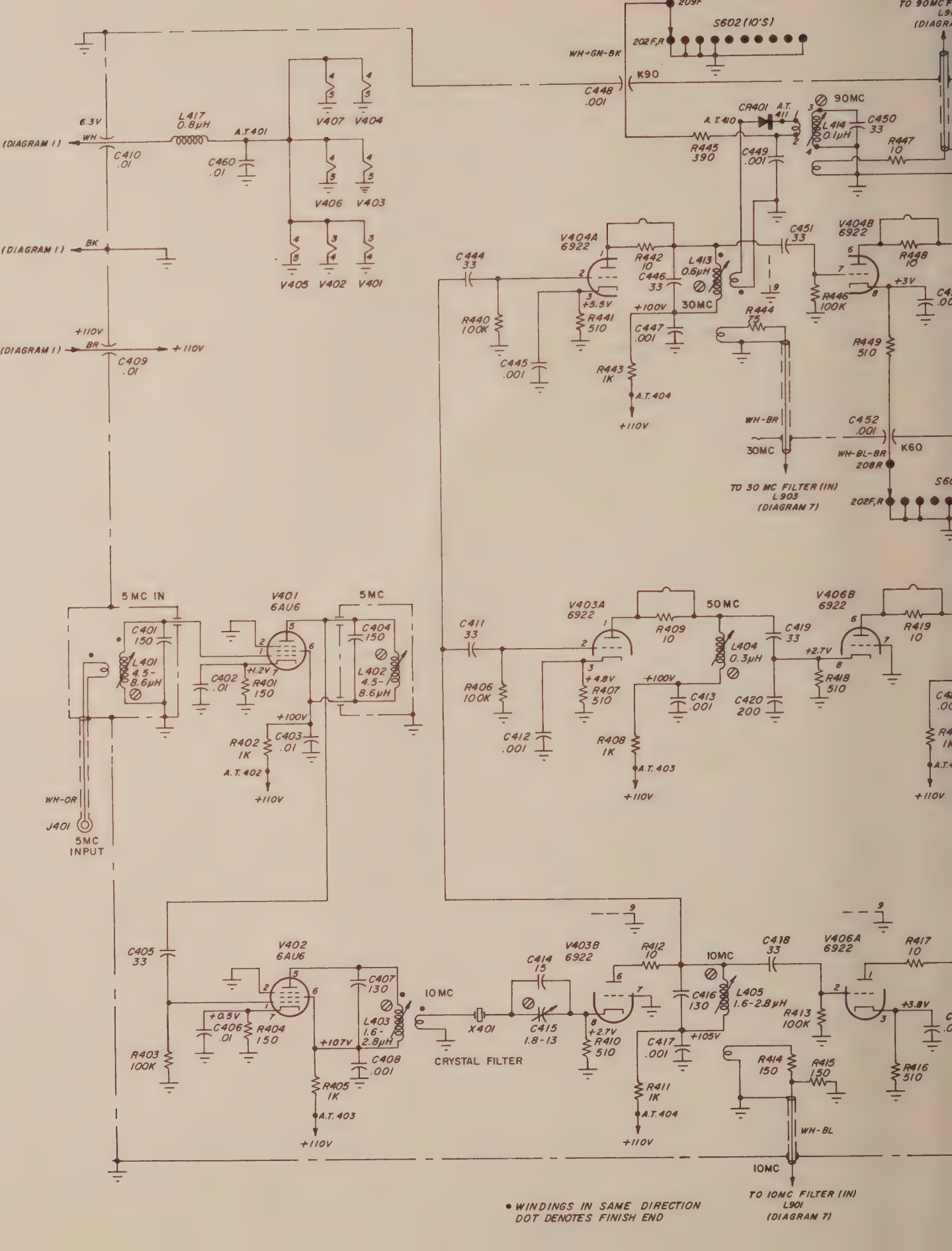


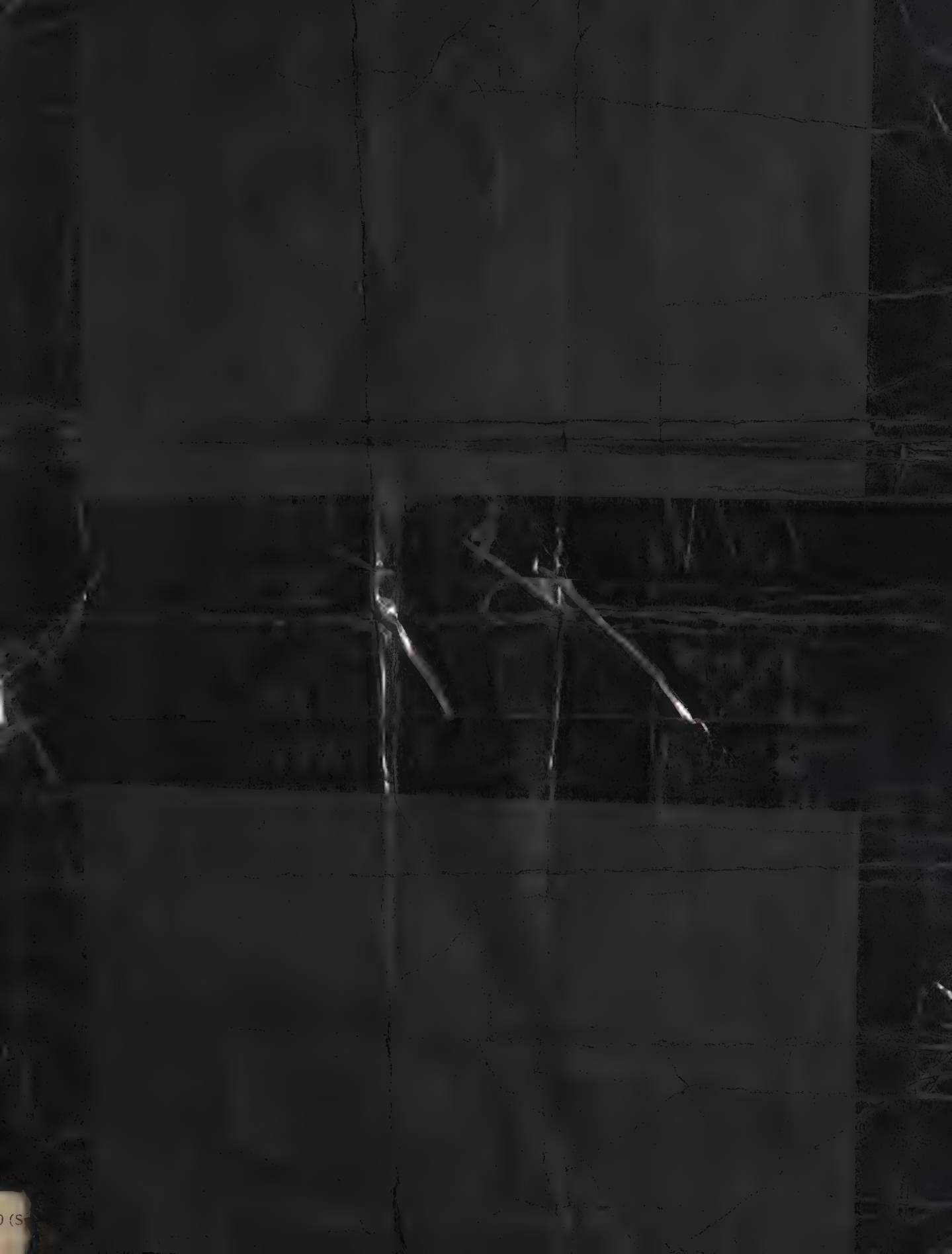
Figure 5.8. 10's Reference-Frequency Generator (shield cover removed).

RESISTANCE TABLE*

Tube	(Type)	Pin	Resistance to Ground (ohms)
V401	(6AU6)	1	5
		2	0
		5	1455
		6	1450
		7	750
V402	(6AU6)	1	100 k
		2	0
		5	1455
		6	1450
		7	150
V403	(6922)	1	1450
		2	100 k
		3	510
		6	1460
		7	0
		8	510
V404	(6922)	1	1455
		2	100 k
		3	510
		6	1450
		7	100 k
		8	510 (Switch S602 on 00, 10, 20, 40, or 60)
V405	(6922)	1	1450
		2	100 k
		3	510
		6	1450
		7	100 k
		8	510 (Switch S602 on 00, 10, 20, 30, 40, 60, or 80)
V406	(6922)	1	1460
		2	100 k
		3	510
		6	1450
		7	0
		8	510
V407	(6922)	1	1450
		2	100 k
		3	510
		6	1450
		7	100 k
		8	510 (Switch S602 on 50, 70, 80, or 90)

*Refer to notes on page 19.


S602 (10'S)
202F,R
WH-GN-BK
K90
C448 .001
90MC
CR401
A.T. 411
A.T. 410
C450 33
L414 0.1μH
R447 10
R445 390
C449 .001
6.3V
WH
(DIAGRAM 1)
L417 0.8μH
A.T. 401
C410 .01
C460 .01
V407 V404
V406 V403
V405 V402 V401
BK
+110V
BR
C409 .01
V404A 6922
C444 33
R442 10
C446 33
L413 0.6μH
30MC
C451 33
V404B 6922
R448 10
R446 100K
+3V
R440 100K
R441 510
+3.5V
+100V
C447 .001
R444 75
C445 .001
R443 1K
A.T. 404
R449 510
WH-BR
C452 .001
K60
WH-BL-BR
208R
TO 30 MC FILTER (IN) L903 (DIAGRAM 7)
5MC IN
V401 6AU6
5MC
C401 150
L401 4.5-8.6μH
C402 .01
+1.2V
R401 150
C404 150
L402 4.5-8.6μH
+100V
R402 1K
C403 .01
A.T. 402
WH-OR
J401
5MC INPUT
V403A 6922
50MC
C411 33
R409 10
L404 0.3μH
C419 33
V406B 6922
R419 10
+2.7V
R406 100K
R407 510
+4.8V
C413 .001
C420 200
R418 510
C412 .001
R408 1K
A.T. 403
C405 33
V402 6AU6
C407 130
10MC
C414 15
V403B 6922
R412 10
C418 33
V406A 6922
R417 10
+0.5V
C406 .01
R404 150
L403 1.6-2.8μH
X401
C415 1.8-13
+2.7V
R410 510
C416 130
L405 1.6-2.8μH
+3.8V
R403 100K
+107V
C408 .001
CRYSTAL FILTER
C417 .001
+105V
R413 100K
R414 150
R415 150
R416 510
R405 1K
R411 1K
WH-BL
10MC
TO 10MC FILTER (IN) L901 (DIAGRAM 7)
• WINDINGS IN SAME DIRECTION DOT DENOTES FINISH END



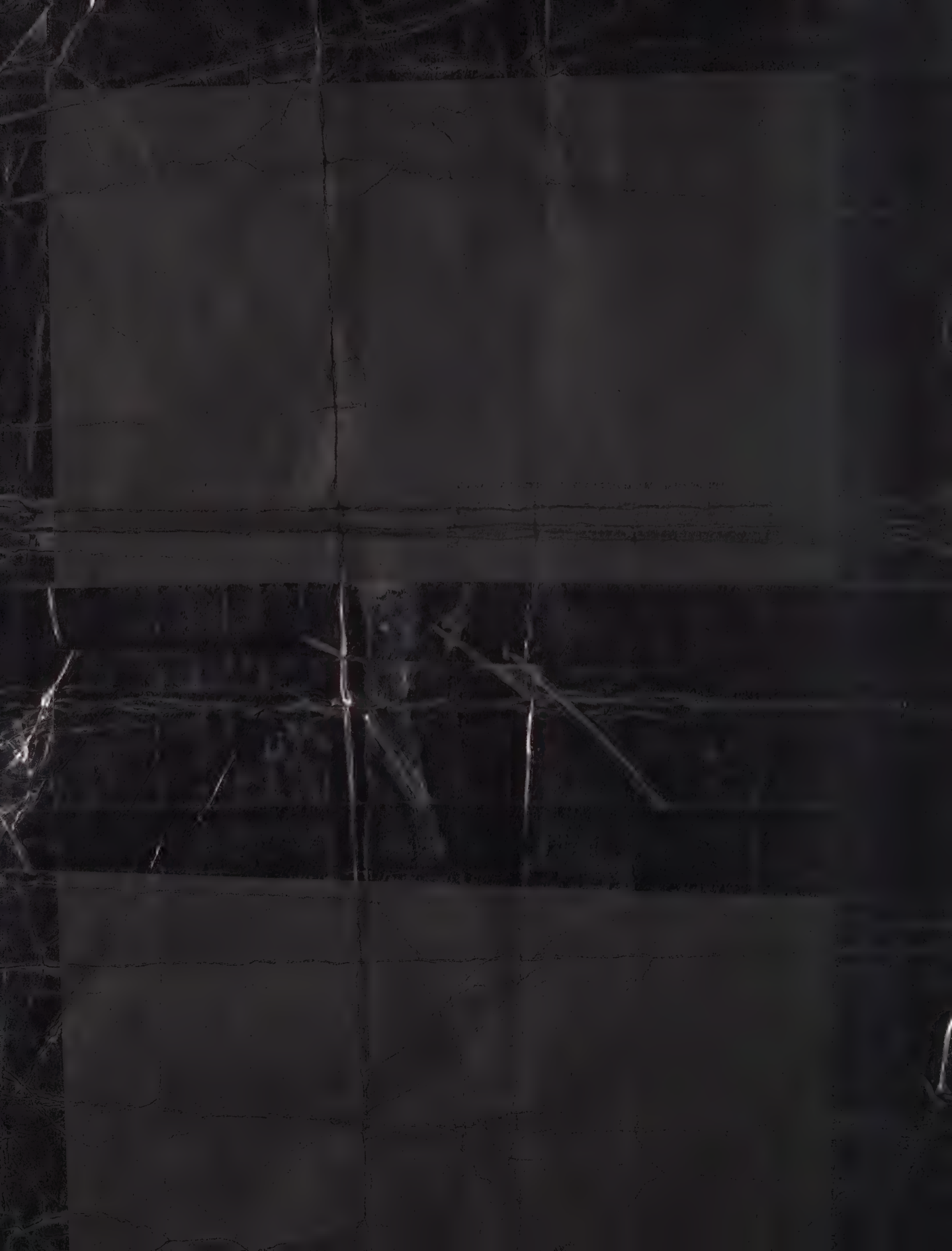
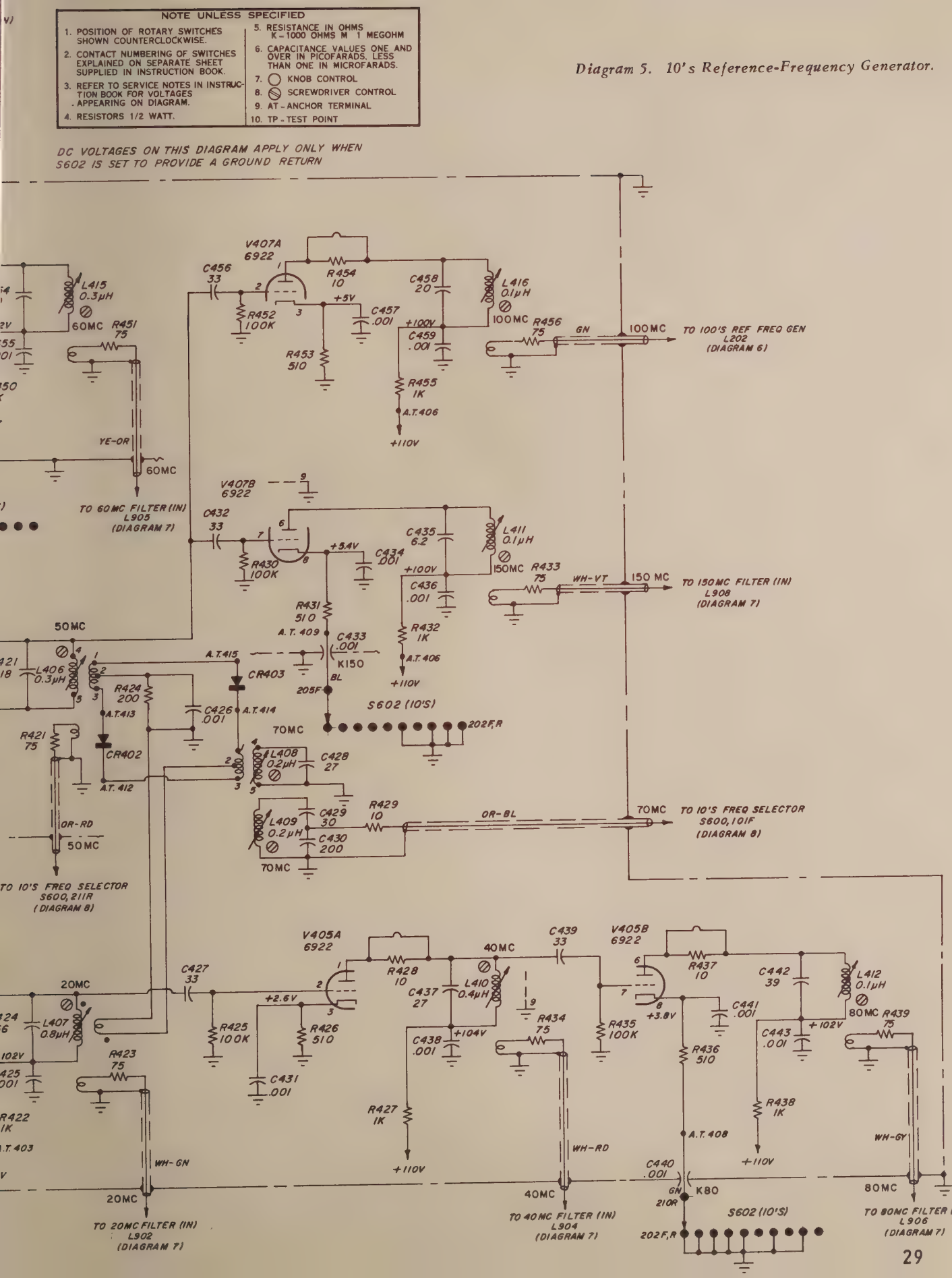


Diagram 5. 10's Reference-Frequency Generator.



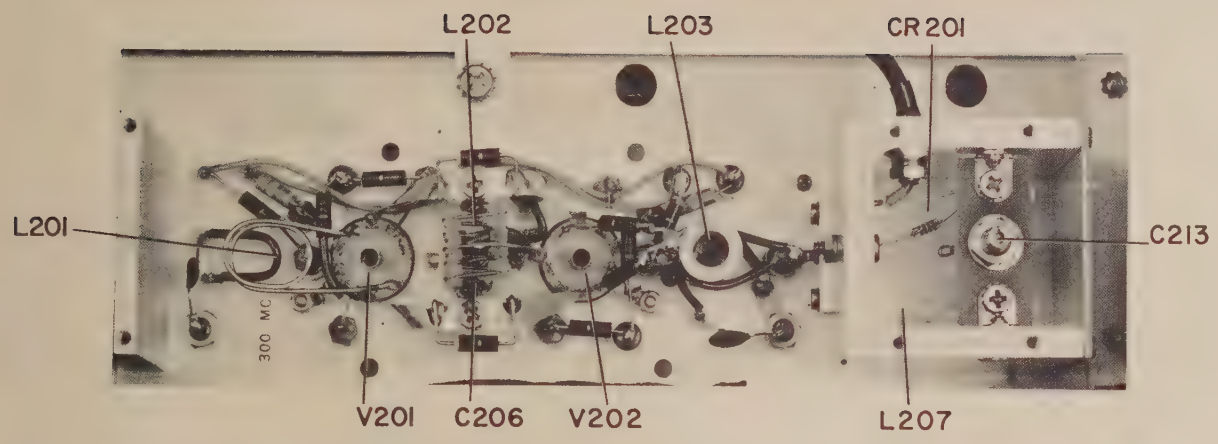
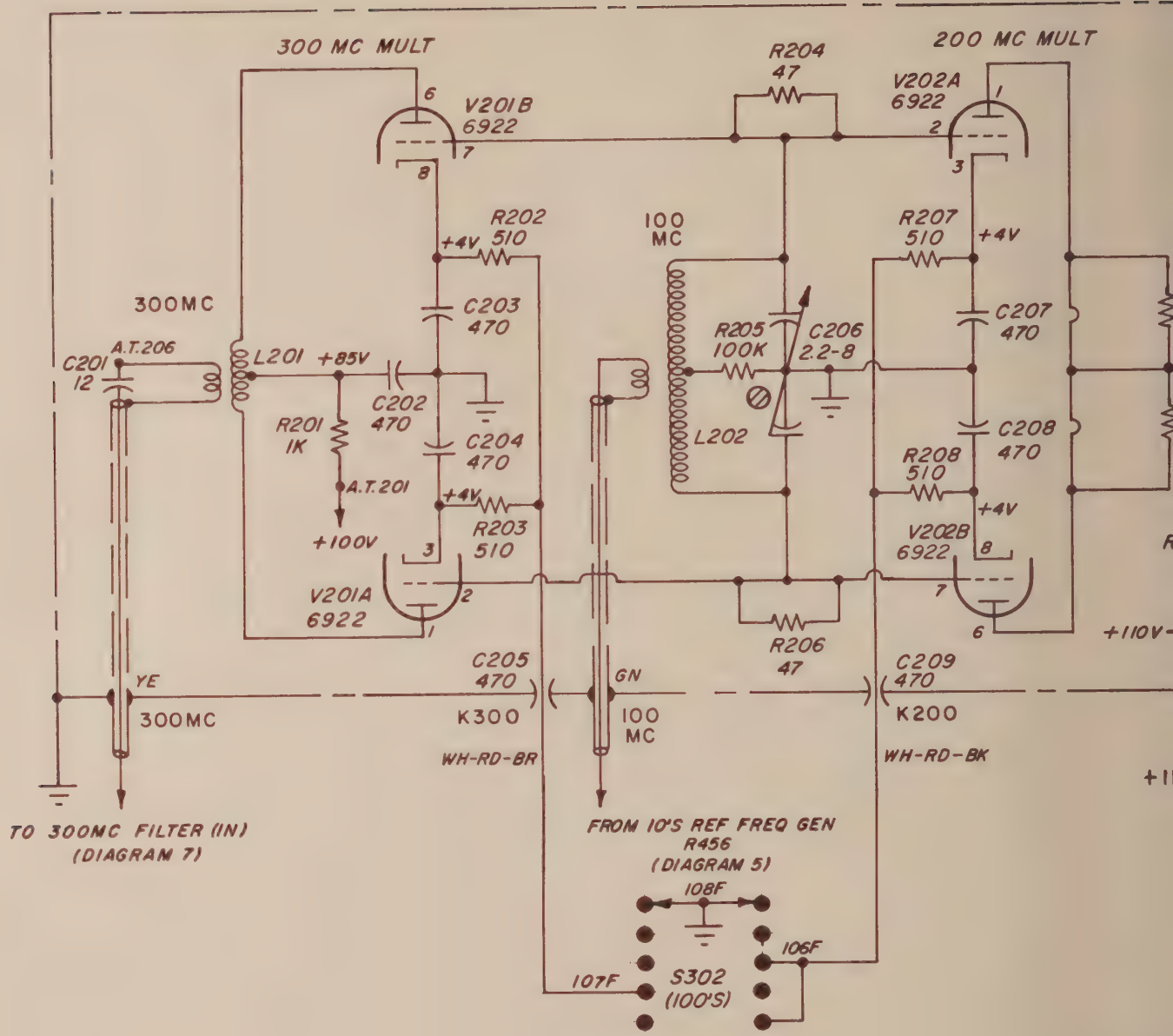


Figure 5-9. 100's Reference-Frequency Generator (shield cover removed).

PARTS LIST

REF NO.	DESCRIPTION - RESISTORS	PART NO.
R201	Composition, 1kΩ ±5% 1/2w	6100-2105
R202	Composition, 510Ω ±5% 1/2w	6100-1515
R203	Composition, 510Ω ±5% 1/2w	6100-1515
R204	Composition, 47Ω ±5% 1/2w	6100-0475
R205	Composition, 100kΩ ±5% 1/2w	6100-4105
R206	Composition, 47Ω ±5% 1/2w	6100-0475
R207	Composition, 510Ω ±5% 1/2w	6100-1515
R208	Composition, 510Ω ±5% 1/2w	6100-1515
R209	Composition, 10Ω ±5% 1/2w	6100-0105
R210	Composition, 10Ω ±5% 1/2w	6100-0105
R211	Composition, 1kΩ ±5% 1/2w	6100-2105
R212	Composition, 300Ω ±5% 1/2w	6100-1305
R213	Composition, 51Ω ±5% 1/2w	6100-0515
	CAPACITORS	
C201	Ceramic, 12pf ±5% N33 500dcwv	4410-0125
C202 thru C204	Ceramic, 470pf ±20% 500dcwv	4400-1500
C205	Ceramic, 470pf ±20% 500dcwv	4400-2000
C206	Air, 2.2-8pf	4380-2003
C207	Ceramic, 470pf ±20% 500dcwv	4400-1500
C208	Ceramic, 470pf ±20% 500dcwv	4400-1500
C209	Ceramic, 470pf ±20% 500dcwv	4400-2000
C210	Ceramic, 470pf ±20% 500dcwv	4400-1500
C211	Ceramic, 20pf ±5% N33 500dcwv	4411-0205
C212	Ceramic, 0.001µf +100-0% 500dcwv	4400-1800
C213	Air, 2.7-10.8pf	4380-2300
C214	Ceramic, 470pf ±20% 500dcwv	4400-2000

REF NO.	DESCRIPTION - CAPACITORS	PART NO.
C215	Ceramic, 470pf ±20% 500dcwv	4400-2000
C216	Ceramic, 470pf ±20% 500dcwv	4400-1500
C217	Ceramic, 470pf ±20% 500dcwv	4400-1500
	INDUCTORS	
L201		1133-8230
L202		1170-0260
L203		1133-2200
L204 thru L206	0.47µh ±20%	4300-0400
L207		1133-8220
	DIODES	
CR201	1017/1N994	6082-1017
	SWITCHES	
S302		7890-3070
	TUBES	
V201	6922	8380-6922
V202	6922	8380-6922



RESISTA

Tube	(Type)	Pin
V201	(6922)	1
		2
		3
		6
		7
		8
V202	(6922)	1
		2
		3
		6
		7
		8

*Refer to notes on page 19.

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/2 WATT.
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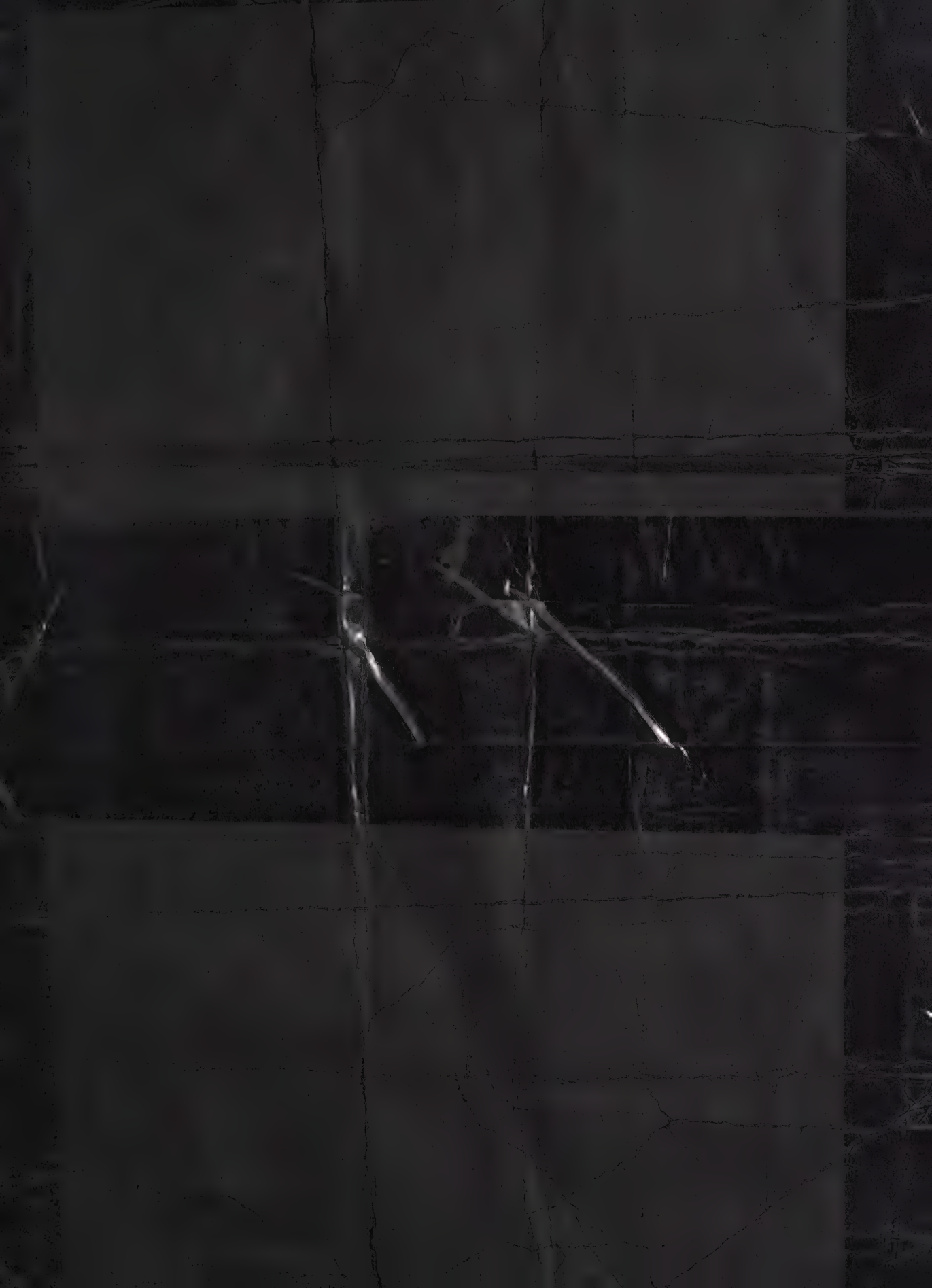
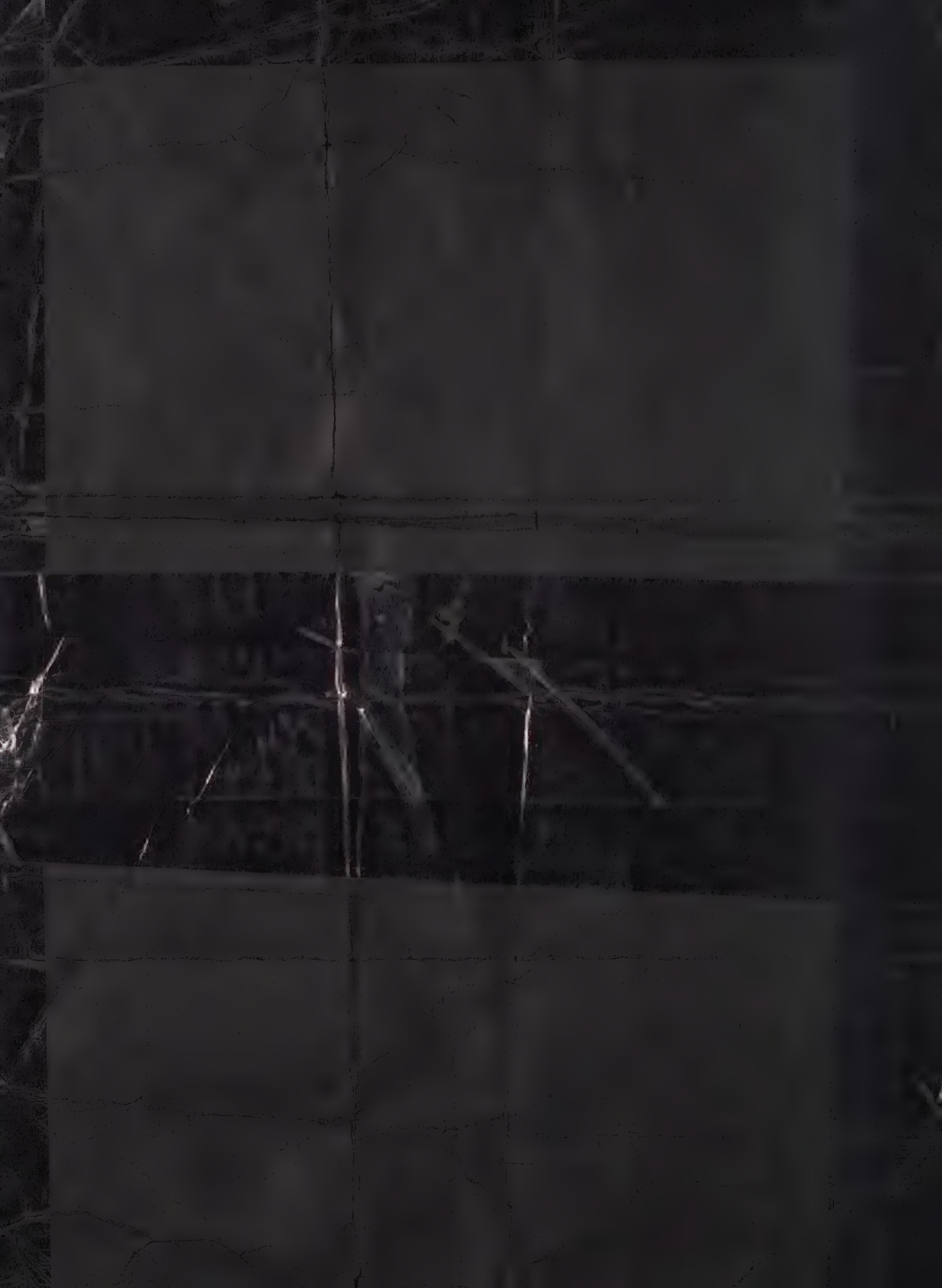
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT = ANCHOR TERMINAL
10. TP = TEST POINT





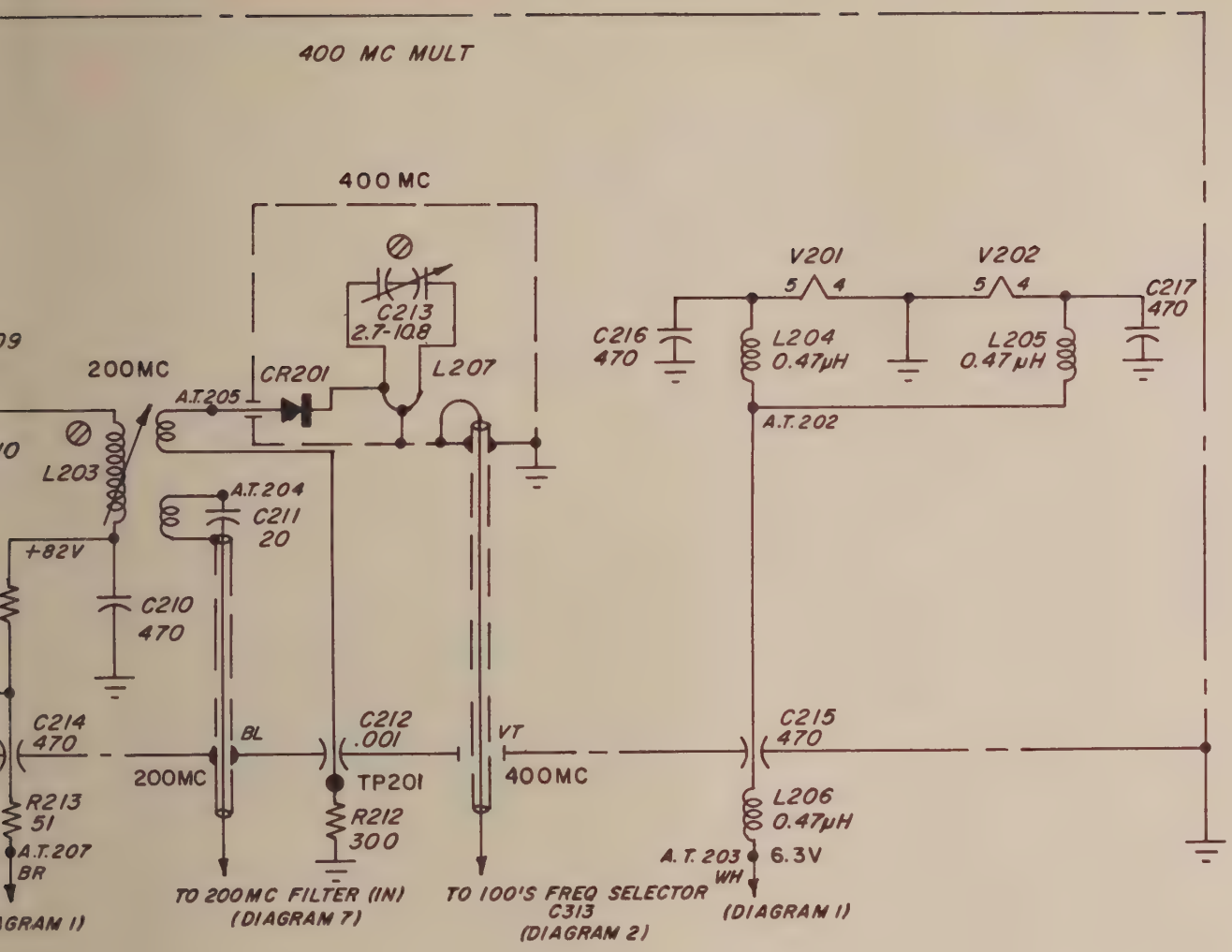


Diagram 6. 100's Reference-Frequency Generator.

TABLE*

	Resistance to Ground (ohms)
	1.5 k
	100 k
510 (Switch S302 on 300)	
	1.5 k
	100 k
510 (Switch S302 on 300)	
	1.5 k
	100 k
0 (Switch 302 on 200 or 400)	
	1.5 k
	100 k
0 (Switch 302 on 200 or 400)	

L901 L902 L903 L904 L905 L906 L907 L908 L909 L910
REFERENCE FREQUENCY FILTERS
10 MC 20 MC 30 MC 40 MC 60 MC 80 MC 90 MC 150 MC 200 MC 300 MC
OUT
IN

Figure 5-10. Reference-Frequency Filters.

PARTS LIST

REF NO.	RESISTORS	PART NO.
C901	Mica, 0.001μf ±5% 300dcwv	4700-1190
C902	Mica, 0.001μf ±5% 300dcwv	4700-1190
C903	Mica, 160pf ±5% 500dcwv	4700-0460
C904	Mica, 510pf ±5% 300dcwv	4700-0613
C905	Mica, 68pf ±5% 500dcwv	4700-0371
C906	Mica, 330pf ±5% 500dcwv	4700-0516
C907	Ceramic, 36pf ±5% N33 500dcwv	4411-0365
C908	Mica, 240pf ±5% 500dcwv	4700-0521
C909	Ceramic, 15pf ±5% N33 500dcwv	4411-0155
C910	Mica, 160pf ±5% 500dcwv	4700-0460
C911	Ceramic, 16pf ±5% N33 500dcwv	4411-0165
C912	Mica, 130pf ±5% 500dcwv	4700-0439
C913	Ceramic, 16pf ±5% N33 500dcwv	4411-0165
C914	Ceramic, 13pf ±5% N33 500dcwv	4411-0135
C915	Ceramic, 13pf ±5% N33 500dcwv	4411-0135
C916	Mica, 110pf ±5% 500dcwv	4700-0413

REF NO.	CAPACITORS	PART NO.
C917	Ceramic, 13pf ±5% N33 500dcwv	4411-0135
C918	Ceramic, 11pf ±5% N33 500dcwv	4411-0115
C919	Ceramic, 51pf ±5% N33 500dcwv	4411-0515
C920	Ceramic, 10pf ±5% N33 500dcwv	4411-0105
C921	Ceramic, 33pf ±5% N33 500dcwv	4411-0335
C922	Ceramic, 10pf ±5% N33 500dcwv	4411-0105

REF NO.	DIODES	PART NO.
L901 thru L907	0.5μh	1133-2900
L908	0.09μh	1133-2901
L909	0.07μh	1133-2902
L910	0.07μh	1133-2902

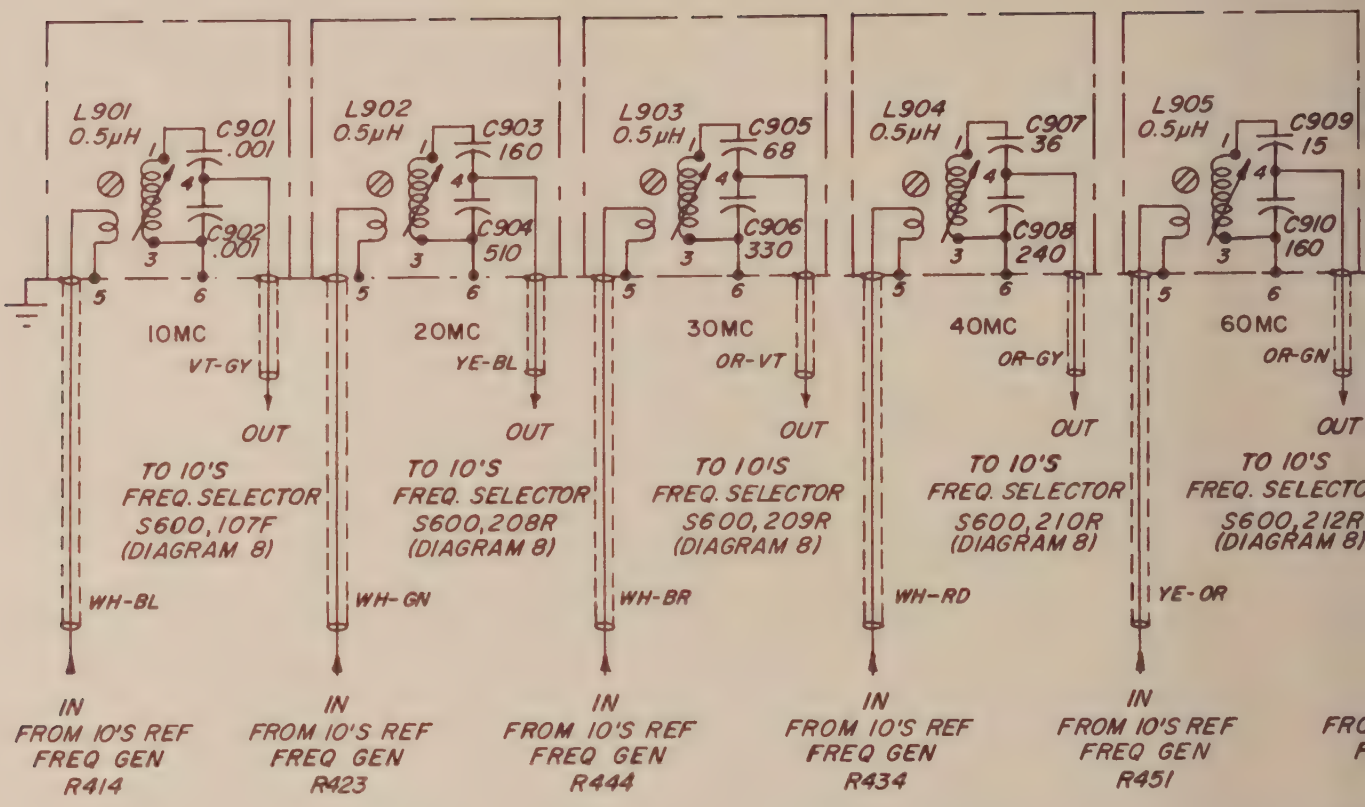


DIAGRAM 5

NOTE UNLESS SPECIFIED

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4. RESISTORS 1/2 WATT.
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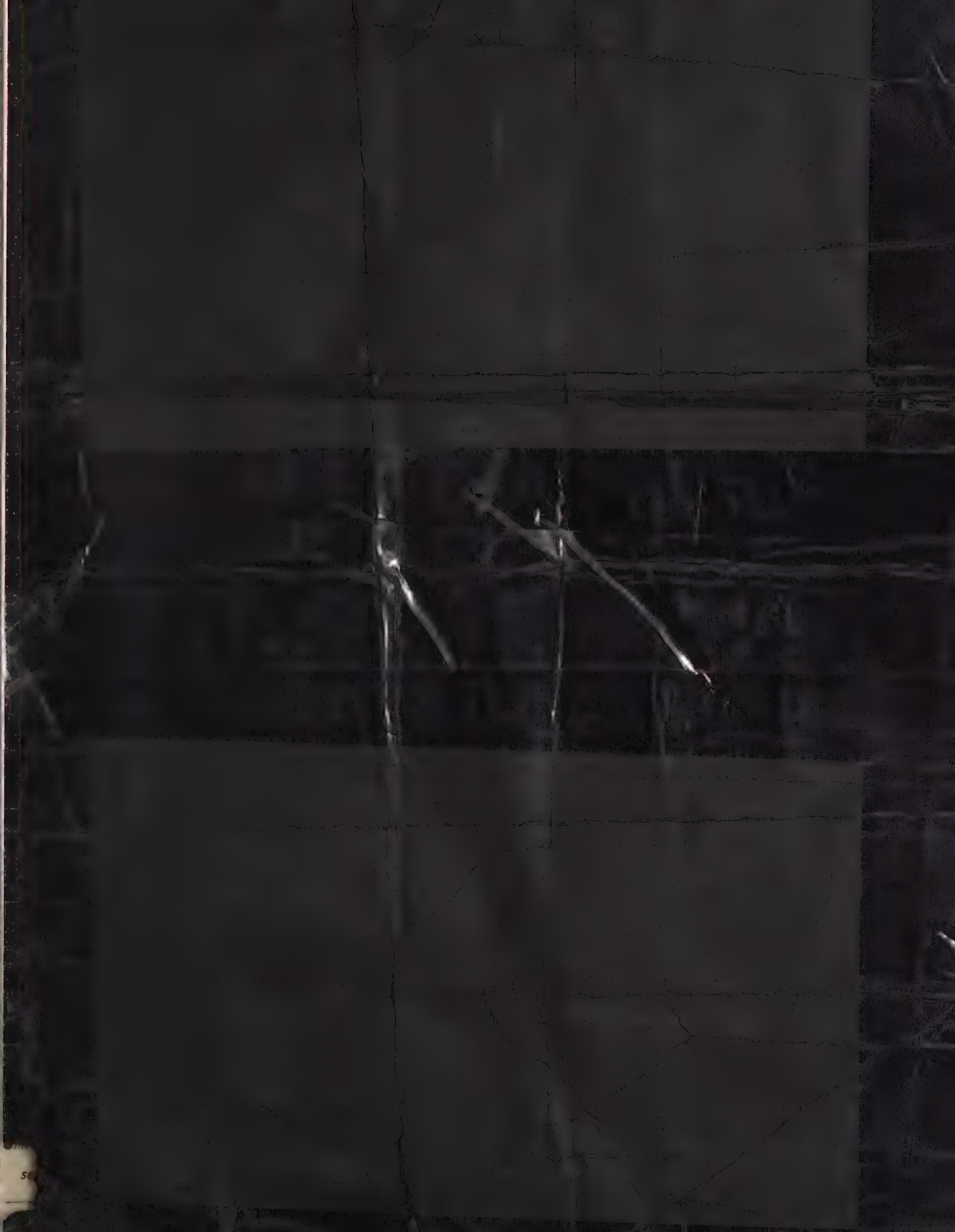
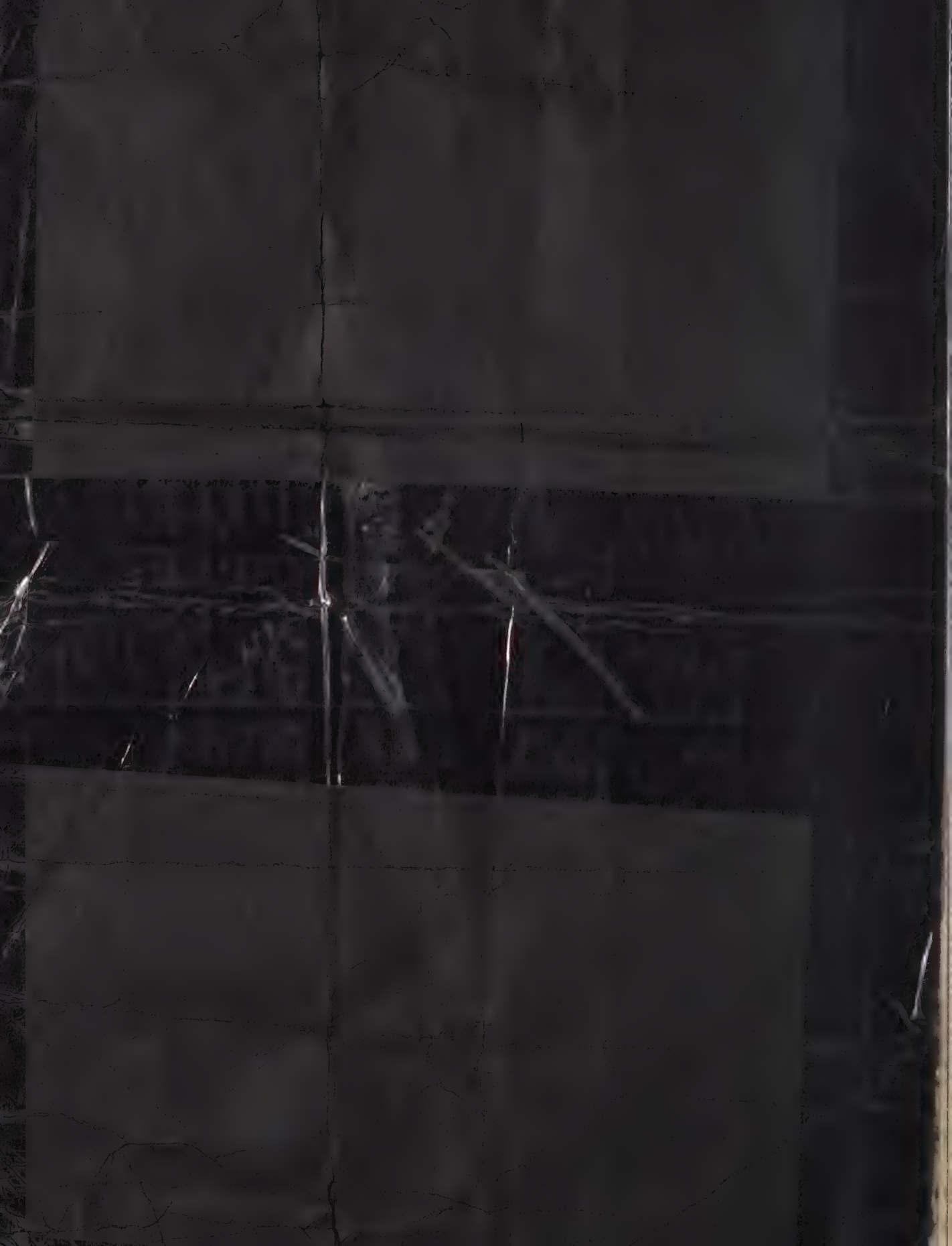
8. ⊘ SCREWDRIVER CONTROL
9. AT = ANCHOR TERMINAL
10. TP = TEST POINT





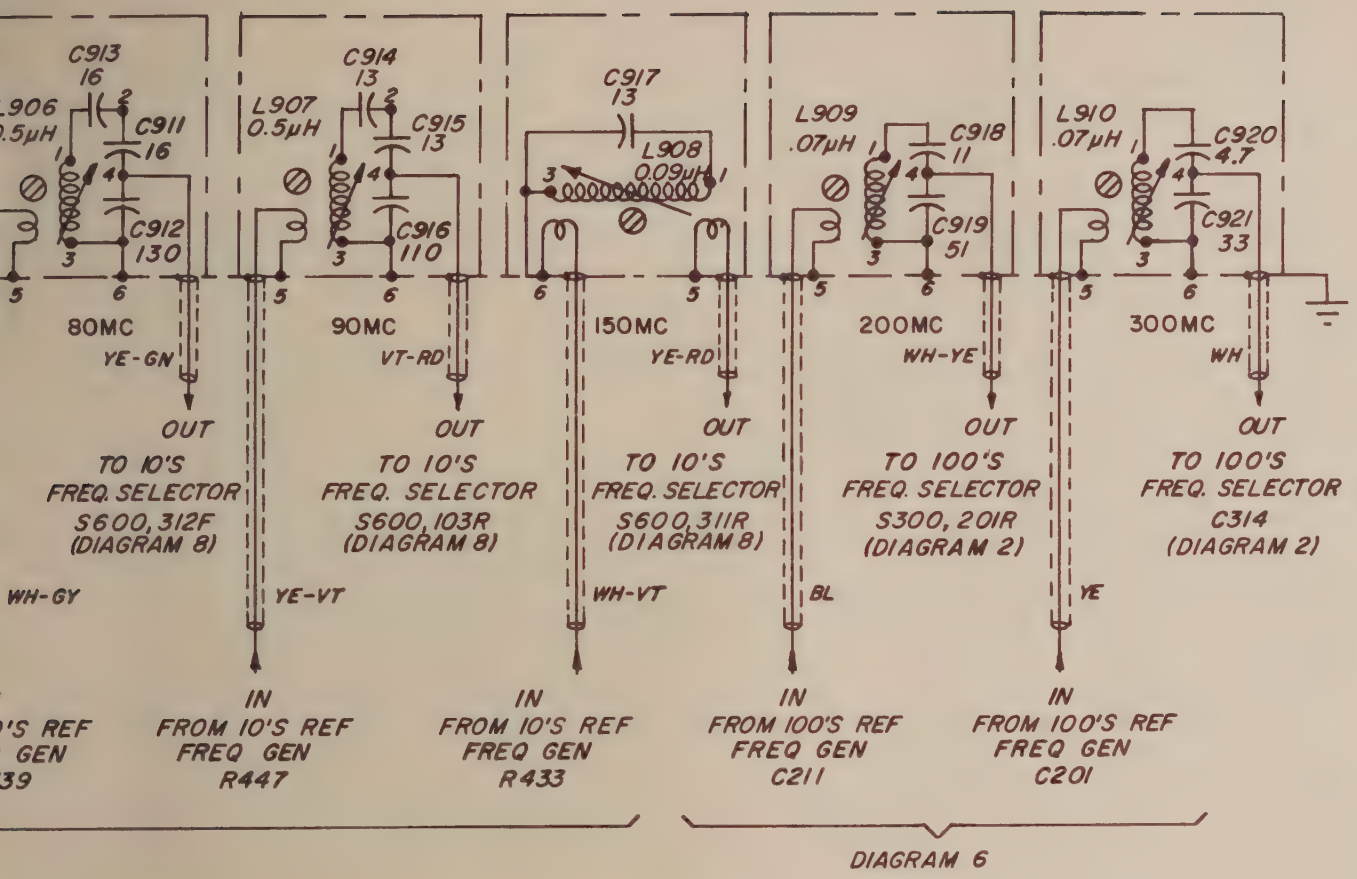


Diagram 7. Reference-Frequency Filters.

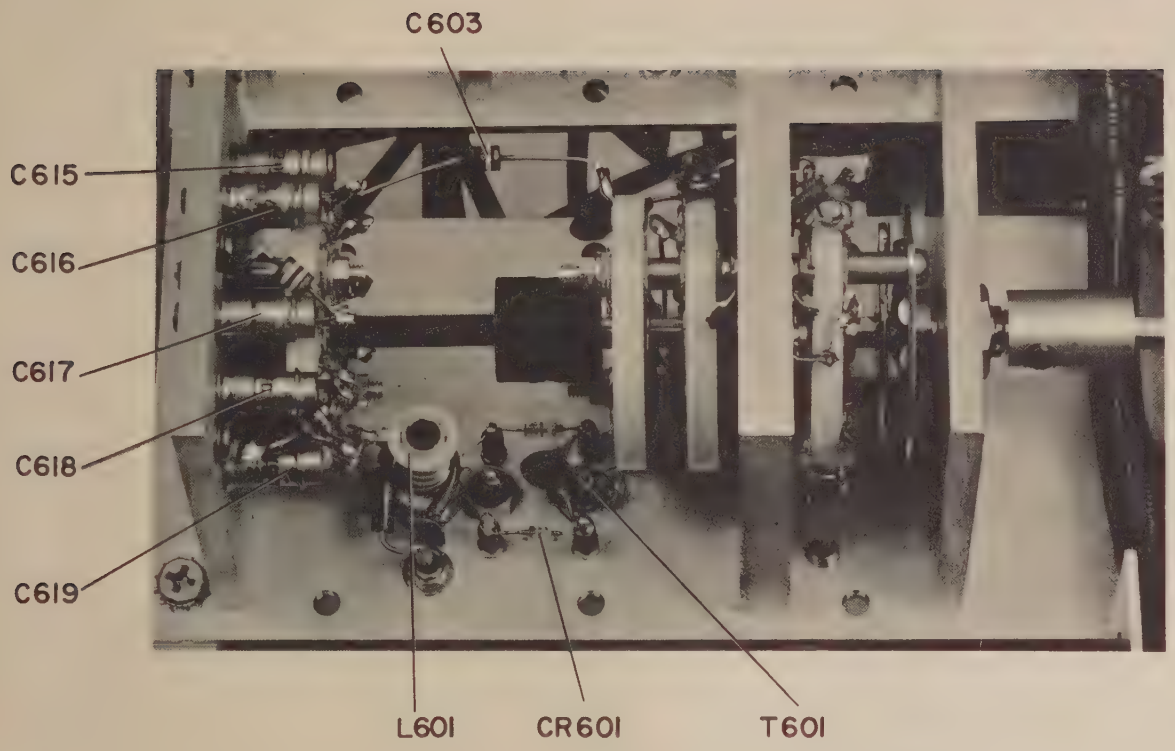


Figure 5-11. 10's Frequency Selector (shield cover removed).

PARTS LIST

REF NO.	RESISTORS	PART NO.
R601 thru R606	Composition, 510Ω ±5% 1/2w	6100-1515
R607	Composition, 75Ω ±5% 1/2w	6100-0755
R608	Pot., Composition, 100Ω ±10%	6010-0150
	CAPACITORS	
C602	Ceramic, 30pf ±5% N33 500dcwv	4411-0305
C603	Ceramic, 2.2pf ±5% 500dcwv	4400-0205
C604	Ceramic, 10pf ±5% N33 500dcwv	4411-0105
C606	Ceramic, .001μf +100-0% 500dcwv	4400-2049
C607	Ceramic, 3.9pf ±5% 500dcwv	4400-0600
C608	Ceramic, 7.5pf ±5% 500dcwv	4400-0900
C609	Ceramic, 10pf ±5% N33 500dcwv	4411-0105
C610 thru C619	Trimmer, 0.8-8.5pf	4910-2000

REF NO.	INDUCTORS	PART NO.
L601	0.1μh	1133-2600
	DIODES	
CR601	1017/1N994	6082-1017
CR602	1017/1N994	6082-1017
	SWITCHES	
S600		7890-3130
S601		7890-3140
	TRANSFORMER	
T601		1133-2620

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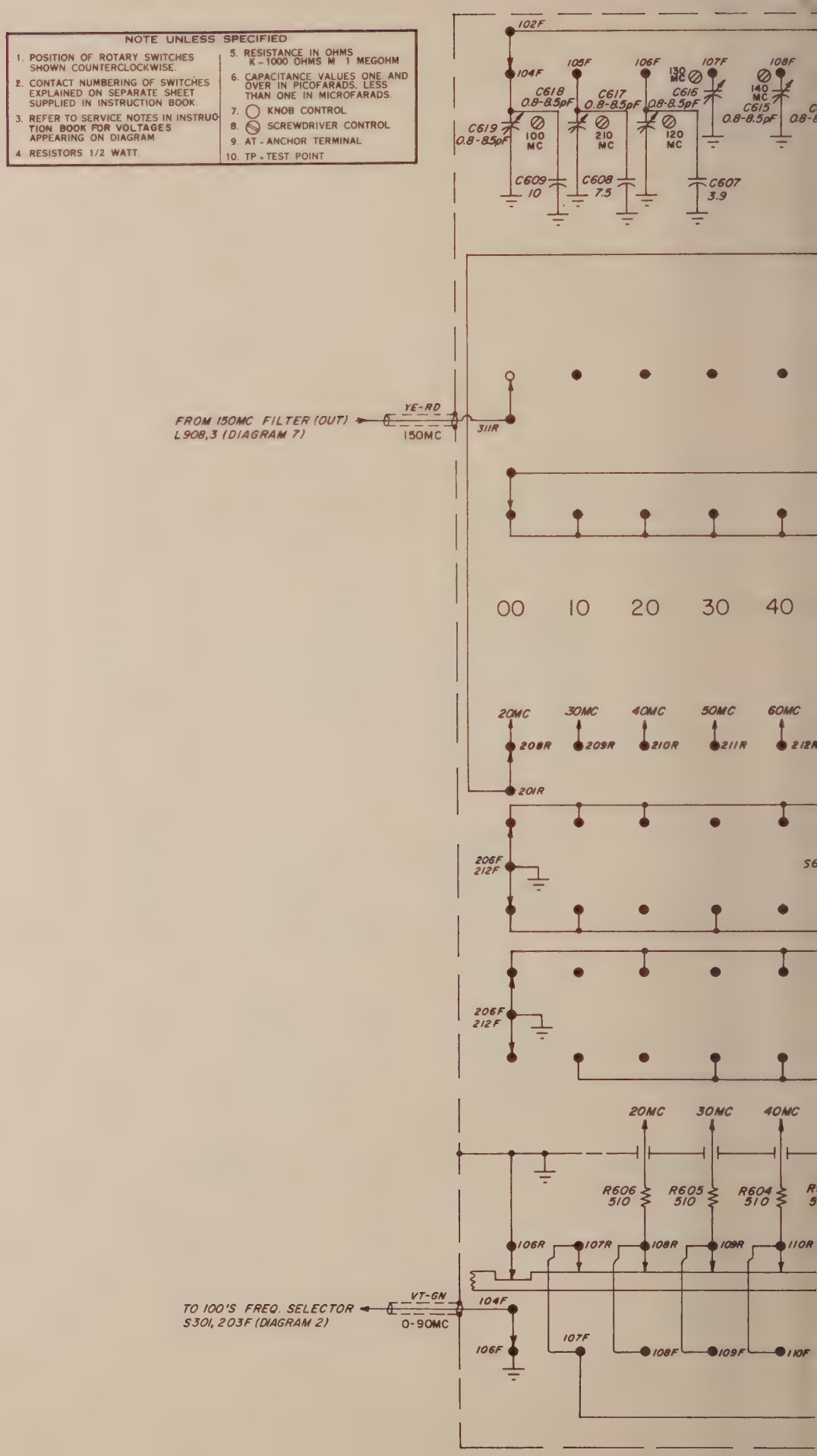
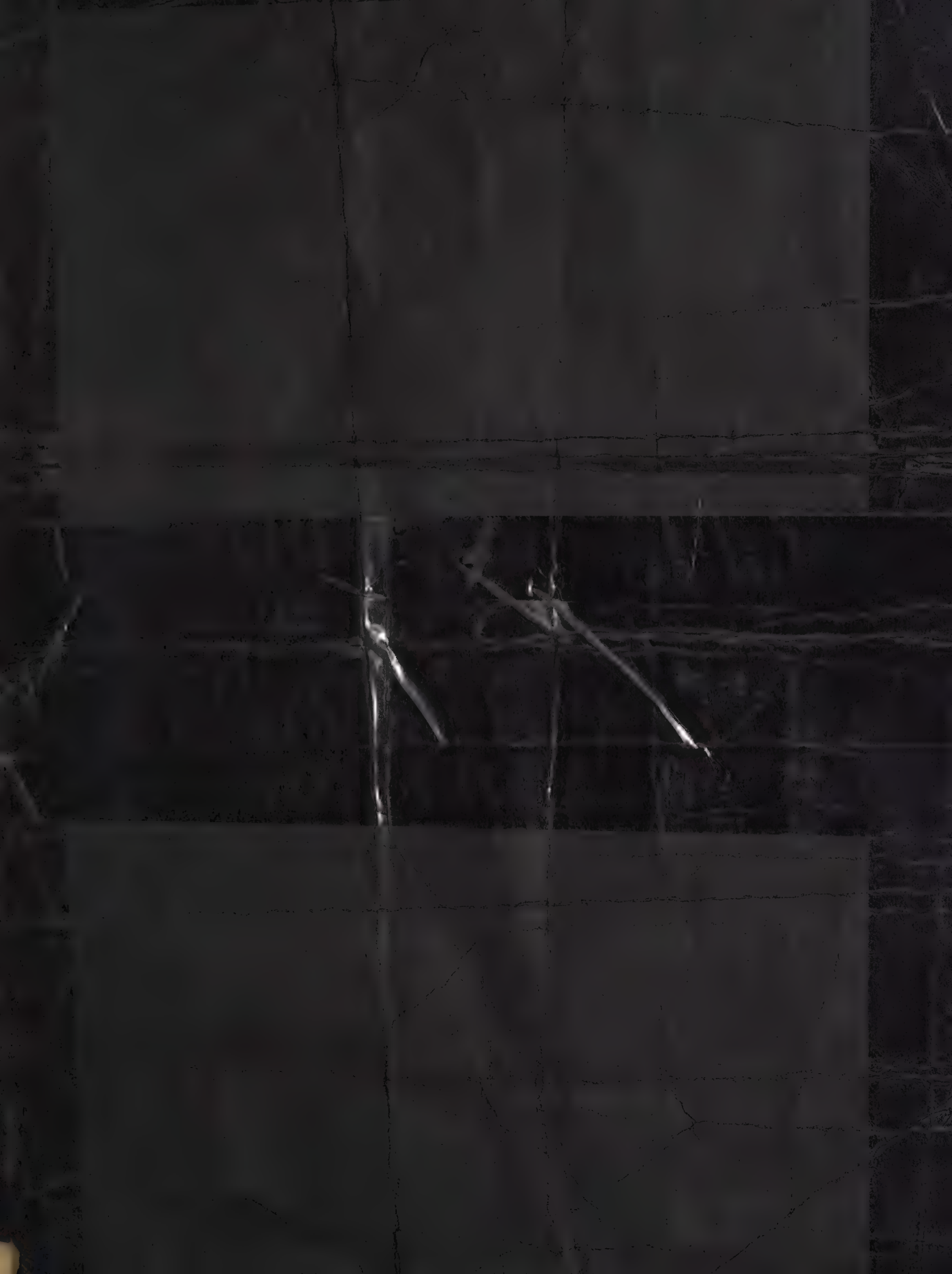
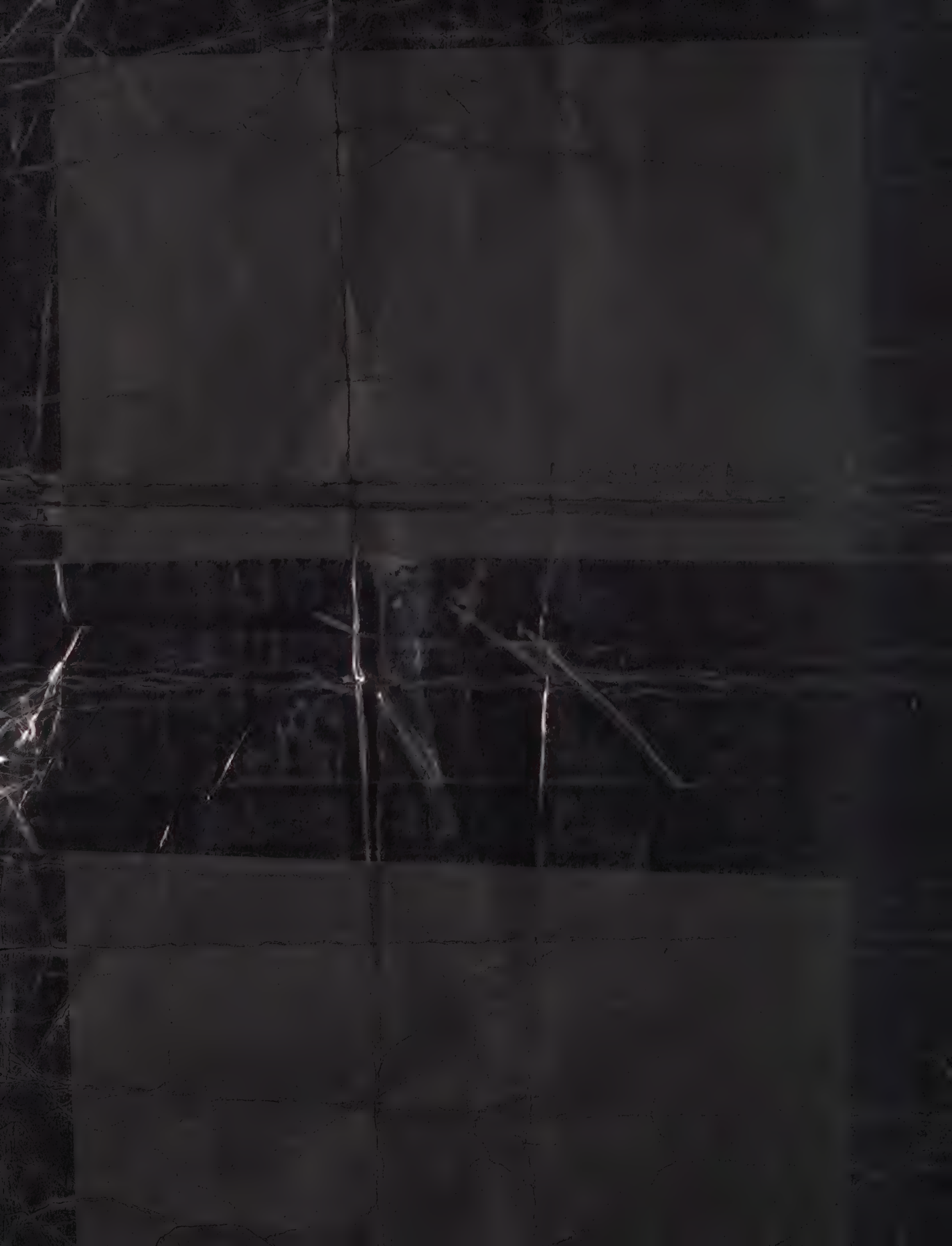
10. TP - TEST POINT







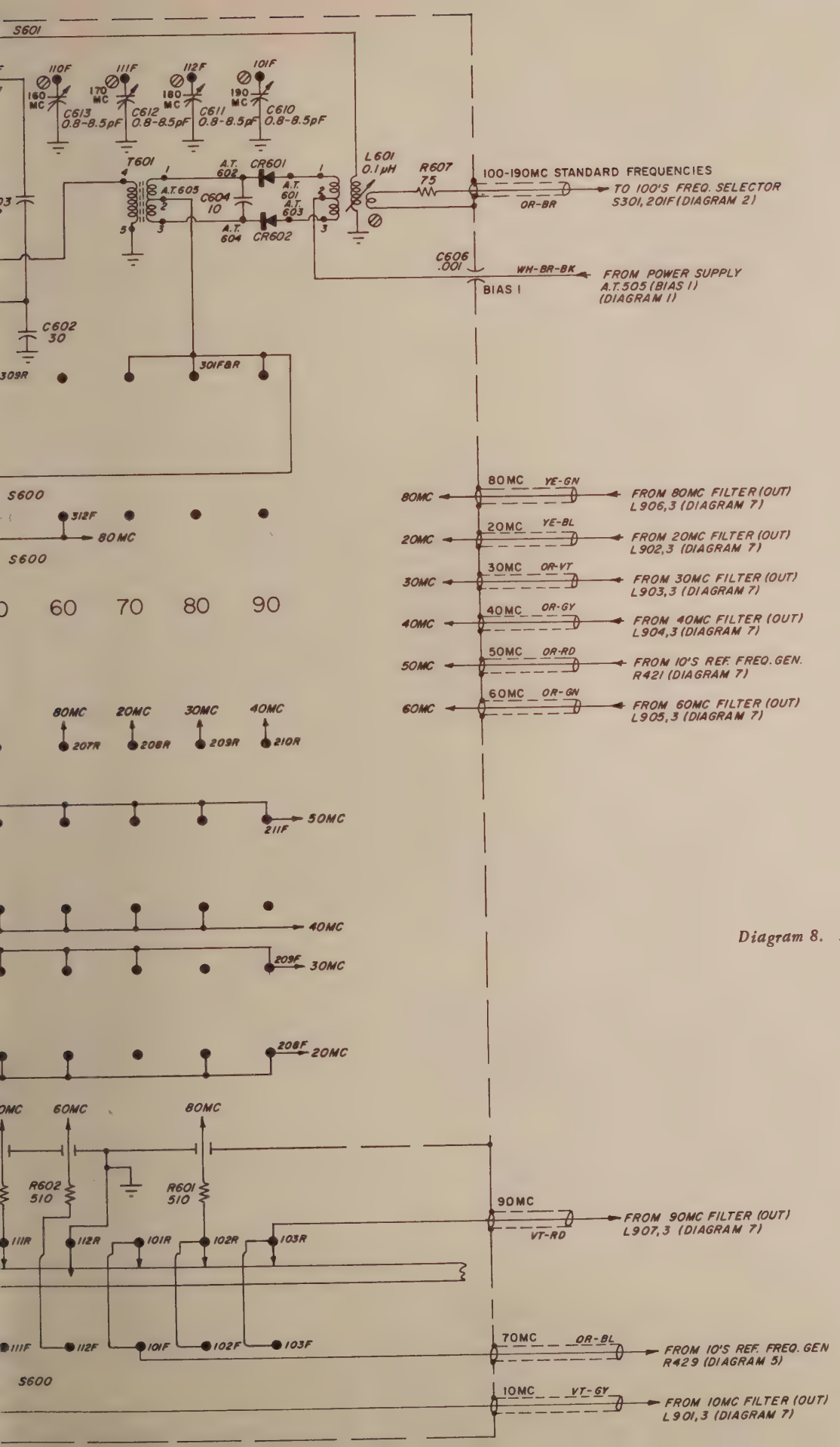
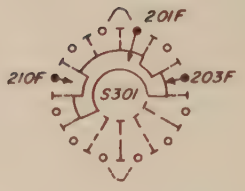
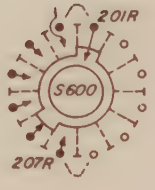
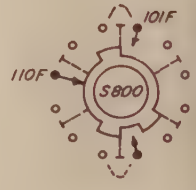
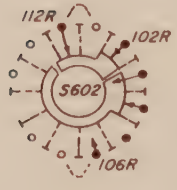


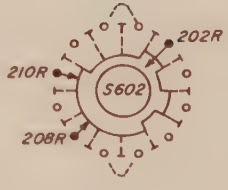
Diagram 8. 10's Frequency Selector.

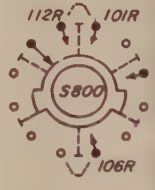


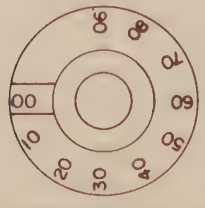




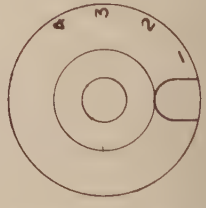






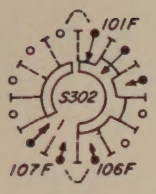


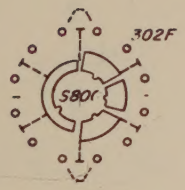
ENGRAVING FOR S602

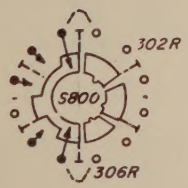


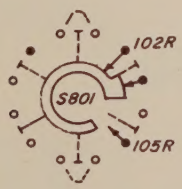
ENGRAVING FOR S302

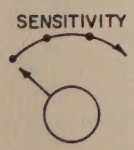
Diagram 9. Rotary Sw





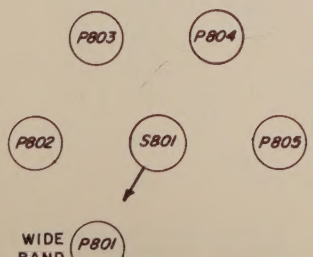






SET TO MIN
REQUIRED

ENGRAVING FOR S303



ENGRAVING FOR S801

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